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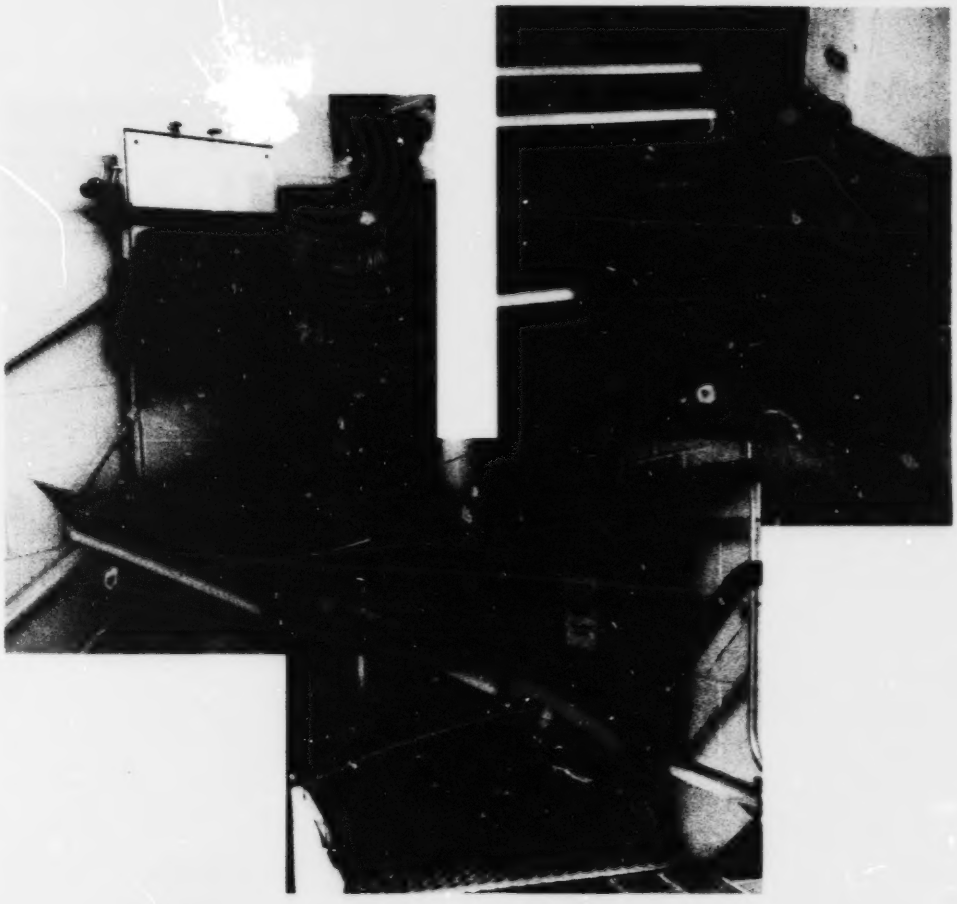
STAIRWAY LIFT ASSESSMENT:

AN EVALUATION OF SELECTED AUTOMATED INCLINED STAIRWAY ELEVATING DEVICES FOR TRANSPORTATION TERMINALS



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TRANSPORTATION DEVELOPMENT CENTRE

BY

DeLCan

MARCH 1984

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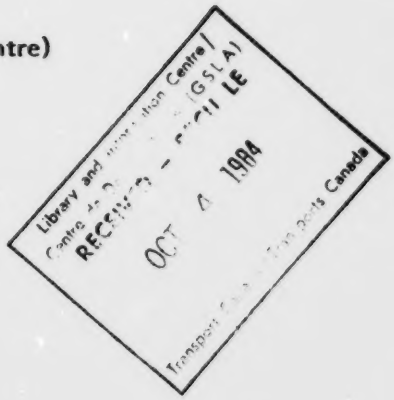
TP 5290E

Stairway Lift Assessment: An evaluation of selected automated inclined stairway elevating devices for transportation terminals

by
Peter Kaulback (DeLCan)
and
Ruth Heron (Transportation Development Centre)



for

Transportation Development Centre
Transport Canada

March 1984

04-1318A-00

"The contents of this report reflect the views of the contractor and not necessarily the officials views or policies of the Transportation Development Centre, Transport Canada."

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17. Abstract

The project consists of an engineering, ergonomic and economic evaluation of selected lifts used in transportation terminals in Canada for facilitating level change for wheelchair passengers.

Four lifts, at three locations, were evaluated by means of site inspections and extensive use of volunteer subjects who were both interviewed and photographed. Attention was paid to factors affecting suitability of the device for both the passenger and the operator. Data were also obtained from the manufacturers.

Although the lifts undoubtedly make transfer easier for wheelchair users, they are not without drawbacks. The operating sequence for the devices tends to be unduly complex and repetitious. From the viewpoint of the passengers the lifts are generally acceptable, except that there is commonly anxiety over safety, induced by depth perception and the openness of the device. The intense visual and auditory stimuli associated with the operations are disturbing to passengers and operators alike. The cost of the lift and its installation is not unduly expensive, and is often considerably less than the cost of installation of an elevator. However, use of a stairway lift reduces capacity of the stairway, generally when maximum capacity is desired. The device may thus, despite low cost, not be cost-effective.

The lifts serve an important function in existing terminals as retrofit devices but are unsuitable for incorporation into initial design and are generally less suitable than vertical lifts or elevators, where such can be installed.

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17. Résumé

Le projet comporte une évaluation technique, ergonomique et économique d'un certain nombre d'escaliers mécaniques utilisés dans les gares au Canada pour faciliter les déplacements des passagers en chaise roulante, d'un étage à l'autre.

Des inspections effectuées sur place et une utilisation intensive par des personnes volontaires, à la fois interrogées et photographiées, ont permis d'évaluer le fonctionnement de trois mécanismes d'élévation, implantés en trois endroits différents. On a évalué des paramètres, telle l'utilité du système tant pour le passager que pour l'exploitant. Des données ont par ailleurs été recueillies auprès des fabricants.

Les escaliers élévateurs facilitent sans aucun doute le transport des personnes en chaise roulante, mais ne sont pas sans inconvénient. Leur mode de fonctionnement semble être inutilement complexe et répétitif. Il semble que les passagers en soient, de manières générale, satisfaits, même s'ils craignent fréquemment pour leur sécurité, du fait de l'impression d'ouverture sur le vide qu'ils ressentent, n'étant pas placés à l'intérieur d'une enceinte. Les nombreuses sollicitations visuelles et auditives liées au fonctionnement du système dérangent les passagers et les exploitants. Le coût de l'appareil d'élévation et de son installation n'est pas prohibitif et il est très souvent largement inférieur à celui d'un ascenseur. Il n'en reste pas moins que l'installation d'un escalier mécanique réduit souvent la capacité de la montée d'escalier, justement à un endroit où elle doit être à son maximum. Le dispositif pourrait donc bien ne pas être rentable en dépit de son coût réduit.

Les escaliers mécaniques jouent un rôle important dans les gares existantes lorsqu'il s'agit d'aménager ces dernières après coup, mais leur implantation au stade de la conception initiale des projets est à déconseiller, leur utilité étant généralement inférieure à celle des ascenseurs lorsqu'il est possible d'installer ces derniers.

18. Mots-clés Escalier mécanique, chaise roulante, handicapés physiques, personnes handicapées, transports, gare.	19. Diffusion Le CDT dispose d'un nombre limité d'exemplaires

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Note:

* The sections marked thus * , relating to the ergonomic evaluation of the devices, have been written principally by Dr. Heron based on fieldwork conducted both by Dr. Heron and Mr. Kaulback.

I. INTRODUCTION

1. General

Many transportation terminals require a level change by passengers to accomplish the intermodal transfer function. A number of older terminals did not incorporate any means for level change for wheelchair users, to whom escalators and stairways present a barrier.

Automated inclined stairway elevating devices have been installed for some years in buildings in Canada, commonly in hospitals, churches, colleges and private residences. Some, more recently, have also been installed in transportation terminals.

Increased attention is currently being paid to provision of a barrier free transportation network whereby wheelchair users encounter minimal restrictions. One means of increasing accessibility within transportation terminals is by the retrofitting of terminals by installing stairway elevating devices, or incorporating these devices into the initial design of new facilities.

Although some devices have been installed in terminals in Canada little or no operational data have been collected by which means the suitability of these devices can be evaluated. The objective of this study is to examine four specific devices in terms of technical, economic and ergonomic parameters in order to assess the appropriateness of utilizing automated inclined stairway-mounted wheelchair devices in existing transportation terminals to facilitate level change for travellers with special needs.

The Stairway Lift Assessment project was awarded to DeLCan (De Leuw Cather, Canada Ltd.) in association with TES Limited, after evaluation of proposals submitted in response to request for proposals by the Transportation Development Centre, dated November 30, 1982, file D1450-103-45, Project No. 4441.

2. Scope of the Project

The project was limited to an examination of four selected devices currently in use in transportation terminals in Canada. The selected sites were Ottawa International Airport, where there is a Cheney Wheelchair Lift III in use; Kingston VIA Rail Station, where there are two Garaventa lifts; and Halifax International Airport, the site of another Garaventa lift.

Operational performance data were to be collected at each site and analyzed and interpreted. Ergonomic data on the four devices were also to be collected and analyzed and interpreted with technical assistance from staff of Transportation Development Centre. Preliminary cost/benefit indications were also to be determined for the devices. The end product of the research was to be a report documenting the data collected and analyzed and recommending the potential applicability of automated inclined stairway elevating devices in terminals across Canada.

II. PROJECT METHODOLOGY

1. Engineering Assessment

The technical evaluation of the devices was undertaken principally by staff of TES Ltd., an Ottawa based engineering firm. The engineering evaluation was based on extensive review of the equipment on site, review of all technical data and drawings made available by the manufacturers and review of pertinent documentation, such as Canadian Standards Association document CAN3-B355-M81 Safety Code for Elevating Devices for the Handicapped. Discussions were also held with engineering staff of the manufacturers and appropriate persons responsible for licensing of the devices.

2. Ergonomic Assessment

Data collection for the ergonomic assessment at each site comprised two major components, a task analysis of system operation, and a compilation of reactions of the system's wheelchair users.

The first of these involved a structured protocol in which the tasks of getting wheelchair occupants up and down the stairway were segmented into specific operations. Observations, carried out while the experienced operators performed the tasks, then focused on detection of any mental or physical load associated with each operation and relating these problems to system design features and/or to passenger handling procedures or policies. These observations were supplemented with extensive discussions with those responsible for the operation of the equipment and with numerous still photographs.

Because installation of the lifts represent positive response to recommendations in Obstacles, The Report of the Special Committee on the Disabled and the Handicapped (David Smith, Chairman) February 1981, a crucial aspect of the assessment was considered to be the human factors associated with use of the devices by potential wheelchair travellers. To obtain the relevant details, volunteer wheelchair occupants were photographed at each site while being taken up and down the stairway by an experienced operator, and subsequently interviewed. At Halifax, volunteers also controlled their own ascents and descents by manipulation of a constant-pressure toggle switch not available on the Garaventa lift at Kingston. In the interviews, volunteers were regarded as members of the research team. Nevertheless, to ensure that the essential data were obtained, a semi-structured approach was adopted, the main probes being directed toward the following aspects:

- feelings of conspicuity or depersonalization; of loss of control over sense of order, personal space, dignity, or independence; or of lack of confidence with respect to the attendant or the passenger-handling system;

- sense of anxiety on perception of depth, or with respect to safety of the system;

- sensory annoyance regarding auditory, visual, vibratory, or other stimuli;

- physical discomfort with respect to motion on descent or ascent.

In order to capture spontaneous responses of both operator and user, it had been hoped that a video camera, activated only when the system was in use, could be installed at one or more sites. However, for technical and other reasons, this plan could not be implemented. As a compromise, information supplementary to that described above

was obtained through motion pictures taken intermittently over a two-week period in late July and early August at the Halifax site.

3. Economic Assessment

The undertaking of a conventional cost/benefit study is extensive and is not within the scope of this project. However, in the absence of cost figures the lift evaluation could be based only on engineering and economic considerations which, although extremely important, are insufficient for a basis upon which to make recommendations. Therefore, in order that the evaluation include a cost indicator the economic assessment was designed to give an indication of the order of magnitude of installation of the device. Cost figures for the Cheney and Garaventa lifts were obtained from the manufacturers.

III. PROJECT RESULTS

1. General

1.1 Standards and Inspection

(1) Standards

In April of 1981, the Canadian Standards Association (CSA) introduced Standard CAN3-B355-M81 entitled "Safety Code for Elevating Devices for the Handicapped". Standard B355 is intended "for use by designers, manufacturers, users and regulatory authorities" to ensure that elevating devices can be used safely to lift handicapped people between different levels inside buildings where the use of a regular elevator would not be practical or economically feasible.

The Standard specifies minimum safety requirements related to the design, construction, installation, operation, inspection and testing of elevating devices which are to be specifically used by handicapped passengers. Automated inclined stairway elevating devices are covered by Standard B355 and are termed "Stair Platform Lifts". A stair platform lift is defined as an elevating device, equipped with a carriage (load carrying unit) in the form of a platform, which is non-portable, permanently installed, for transporting handicapped persons between two or more levels by means of a guided carriage moving substantially in the direction of a flight of stairs or ramp at a mean angle of not more than 45°.

Stair platform lifts are further defined as either Type C or D. A Type C lift is one where the lift runway (the space within which the carriage of a lift moves) is guarded so as to physically prevent access to it, while a Type D lift is one where the runway is not guarded. Apparently, when Standard B355 was being formulated, there was considerable discussion as to whether only Type C lifts should be permitted in public buildings. Eventually, it was decided that the Standard should cover technical safety requirements for all generic types of elevating devices for the handicapped which were then on the market, and restrictions with regard to location, type and usage should remain the prerogative of the regulatory authorities.

(2) Inspection

Elevating devices fall under the jurisdiction of the provinces. In general, each province has an Elevator and Lift Act which incorporates CSA Standard CAN3-B355-M8 as part of the act. These acts require that the design and installation of elevating devices be approved by the Provincial Chief Elevator Inspector. In addition to the initial inspection, there is normally a requirement to have the device inspected yearly and for the operator to have the device maintained by a certified elevator mechanic.

Elevating devices located in federal government buildings (such as the two airports and railway station in this program) are not directly under the regulatory authority of the provinces. However, federal government regulations require that the elevating devices comply with the Elevator and Lift Act of the applicable province. The design approval and inspection of elevating devices in federal buildings may not necessarily be performed by provincial authorities since the federal government may subcontract these tasks to qualified firms or individuals. For example, in Ontario, only the design approval and initial inspection of federal elevating devices are performed by the provincial elevator inspectors whereas, in Nova Scotia, the design approval and all inspections are performed by provincial inspectors.

2. The Cheney Stairway Lift III

2.1 General

The Cheney Stairway Lift III evaluated in this project is manufactured by The Cheney Company, 3015 South 163rd Street, New Berlin, Wisconsin 53151 USA (Tel: 414-782-1100). The basic lift has been sold since approximately 1973. Sales have been concentrated in three principal areas; private residences; schools, colleges, universities and hospitals; and commercial buildings. A significant number of units have been installed in institutional buildings such as libraries, courthouses and recreation centres and a number have been installed in churches. A small number of Cheney lifts have been used in transportation terminals but it is believed that only two airports (Milwaukee and Ottawa International) currently have installations.

The Cheney Company have not pursued an aggressive marketing policy in Canada but have sold some twenty or so devices in this country.

2.2 Engineering Evaluation

(1) General

A Cheney stairway lift is installed at the Ottawa International Airport. The device was installed in 1978 and is located at Gate 26 which is a Canadian Pacific Airlines bridge. This bridge is also occasionally used by Air Canada. The lift is situated in a stairwell which has nine risers (steps) with a total level change of 1.6 metres. The lift runway is not guarded and the device is therefore classified as a Type D installation.

The lift is a Cheney Wheelchair Lift III. It is shown in its folded and unfolded configurations in Photographs 1 and 2 (located in the Appendix to this report). This installation is the only Cheney stairway lift which is currently operational at a public transportation facility in Canada. In the United States, this model of Cheney lift is normally used in private residences since regulations in that country do not permit this type of lift, in this configuration, in public buildings.

(2) Lift System

The Cheney stairway lift is shown schematically in Figure 1. The system consists of a carriage assembly, containing the folding platform and drive unit, which rides on two parallel rails which are attached to the stairwell wall. The upper rail is the main support rail and contains a gear rack (see Photographs 3 and 4) which is engaged by a pinion gear on the drive unit. The lower rail does not support any weight but is loaded by horizontal compressive forces. The rails are attached to the wall by various means depending upon the construction details of the supporting wall or the stairs. In the Ottawa installation (see Photograph 2), the rails are attached to the existing wall by steel posts and directly onto an extended wing wall.

The Cheney lift requires a minimum stairway width of 970 mm to provide clearance to fold down the platform. At the lower landing, a minimum of 2750 mm is required, for a front loading platform, from the nose of the first riser to any obstruction. The minimum headroom from the step nose, at a right angle to the slope of the stairs, is 2440 mm. The stairway lift can traverse multiple landings, however, it is limited to going up or down straight stairways.

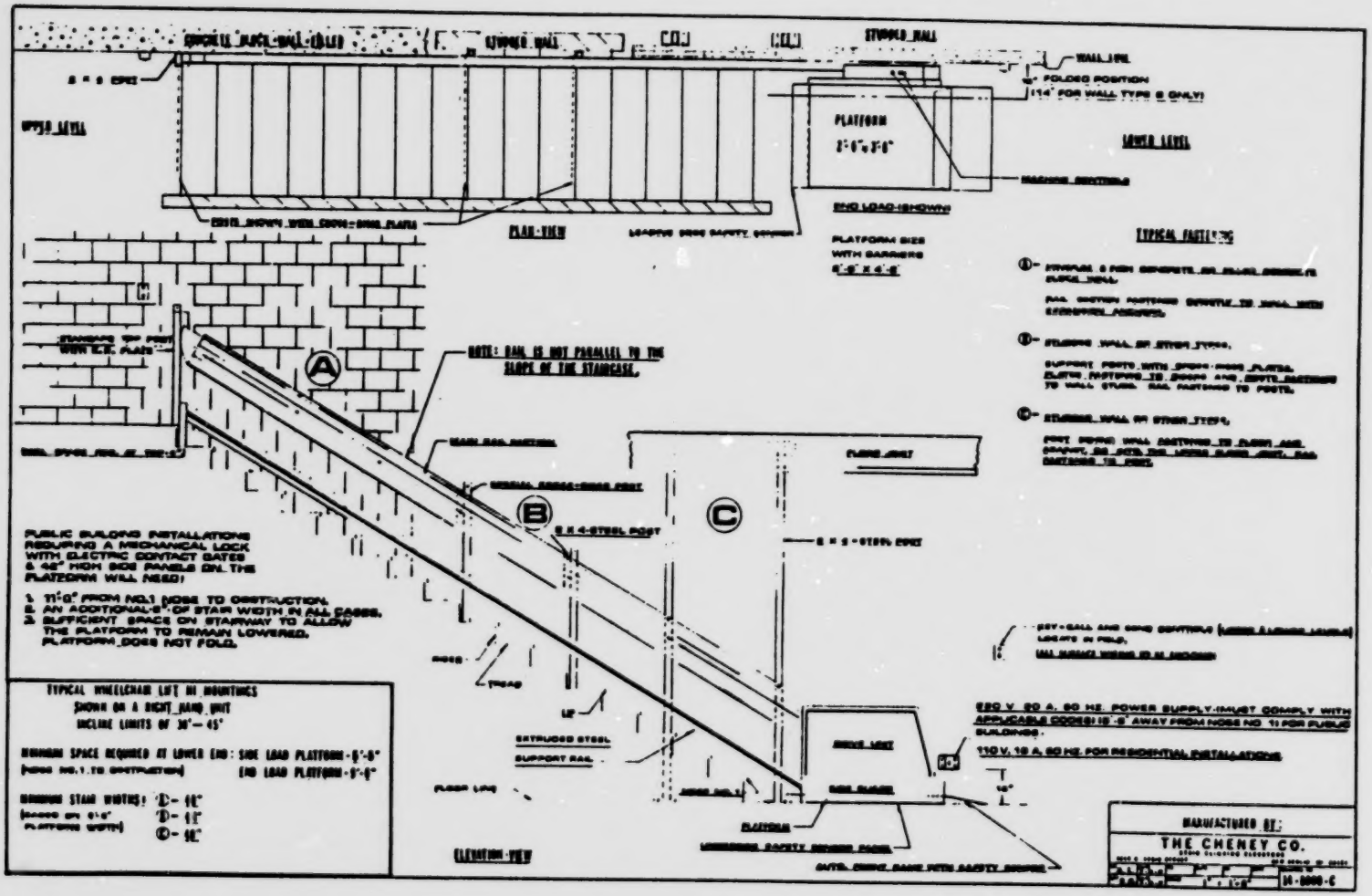

STUDDED WALL
PLATFORM
PLAN VIEW
ELEVATION VIEW
PUBLIC BUILDING INSTALLATIONS REQUIRING A MECHANICAL LOCK WITH ELECTRIC CONTACT GATES & 42" HIGH SIDE PANELS ON THE PLATFORM WILL NEED:
1. 11'-0" FROM NO.1 NOSE TO OBSTRUCTION.
2. AN ADDITIONAL 6" OF STAIR WIDTH IN ALL CASES.
3. SUFFICIENT SPACE ON STAIRWAY TO ALLOW THE PLATFORM TO REMAIN LOWERED. PLATFORM DOES NOT FOLD.
TYPICAL WHEELCHAIR LIFT MOUNTINGS
SHOWN ON A RIGHT HAND UNIT
INCLINE LIMITS OF 30° — 45°
MANUFACTURED BY:
THE CHENEY CO.

FIGURE 1

SCHEMATIC OF CHENEY STAIRWAY LIFT III

(3) Platform

The platform can be folded to a vertical stored position (see Photographs 1 and 3) so that the stairway clearance is reduced by only 329 mm. The lift is normally stored at the lower landing. In the Ottawa installation when the lift is parked, it is moved a short distance up the support rails to avoid protruding past the wing wall (see Photograph 1).

The platform is 770 mm wide and 1120 mm long. The platform is very solidly constructed and, according to the Cheney brochure, it "normally requires an able bodied person to raise and lower". Despite its robust construction, the rated load of the lift is only 150 kg which is less than the minimum rated load of 185 kg specified in Standard B355. Cheney have noted (correspondence to P. Kaulback dated December 16, 1983) that increasing the minimum rated load to comply with Standard B355 is on their long term project schedule but it is unlikely that an uprated lift will be available before 1985. When the platform was occupied by a passenger and wheelchair with a total weight of approximately 100 kg, the outside edge of the platform deflected by approximately 12 mm.

The platform is held in the vertical stored position by a latch mechanism (see Photograph 3). The latch mechanism has been modified in an attempt to prevent accidential unfastening and to avoid damage to the operator's fingers when latching and unlatching the platform. However, the latch mechanism is still cumbersome to use and does not prevent unauthorized or mischievous unlatching and deployment of the platform. Unauthorized use of the platform may not be a problem in this particular installation since access to the area is restricted. However, the latch mechanism is awkward to use and could be redesigned with a positive self-locking latch incorporated into the mechanism.

(4) Drive Mechanism

The drive unit is located on the carriage assembly. It consists of a self-locking positive leadscrew reducer driven by a 560 W electric motor. A driving pinion engages the rack attached to the upper rail. This engagement is positive and, under no circumstances, could the driving gear lose its engagement with the gear rack. This positive engagement does result in a small jerk when the lift is set in motion. See Photograph 5 showing an exposed view of the carriage assembly.

The carriage assembly cannot fall freely except by stripping off all of the teeth. The gear mesh acts as the braking mechanism. According to Cheney, the drive mechanism has a safety factor of over 7 and they have never experienced an accident due to a component failure. In the event of a power failure, there is currently no provision to manually move the carriage assembly, as is required in B355. Passengers and wheelchairs would have to be lifted from the platform by the operator and other attendants. Cheney have noted that it would be a relatively simple matter to provide a hand winding wheel as the worm drive used in the unit has an unused input shaft extension to which it could be connected.

A spring-loaded spool releases and collects the electric cable between the outlet on the lower landing and the drive unit on the carriage. The cable is shown on the top of the upper support rail in Photograph 2. Since the cable is being continuously flexed, it may require periodic maintenance. If the spool failed to work properly, it is possible that the cable might get entangled and damaged by the carriage while it is descending. In Ottawa the cable has suffered some damage and has been repaired with tape (see Photograph 2).

(5) Operation

The lift is always operated by an attendant. The control features for the lift are indicated in Figure 2. There are call/send switches at both upper and lower landings. The location of the upper landing switch can be seen in Photograph 6 (to the right of the passenger's head) and the control is shown in close up in Photograph 7. By means of this switch the lift can be both called up to the top landing or sent down to the lower landing. The key is inserted in the appropriate socket and turned to the right. Constant pressure is required on the key. The lower call/send switch is located on the wing wall adjacent to the lift. This switch can be seen in Photograph 1 and, in close up, in Photograph 8. The same operating instructions apply as for the upper unit, except that the switches are reversed: the upper switch calls the lift down while the lower switch sends the unit up. Note that no indication is provided on the switch box. The hand-held control module (which can be seen in Photographs 1 and 16) is attached to the lift by a jack and socket. The socket is located adjacent to the security bar bracket and immediately to its right is the key control. This is shown in Photograph 9 (note that the jack can be seen in the upper left corner). The control module can only be operated after this key has been turned on by turning to the right. This key is left in the unit during operation, and following use of the lift the key is turned to the off position. The module has two pressure switches, the up switch being located towards the top of the unit and the down switch in the lower half of the unit. These switches require constant application of pressure.

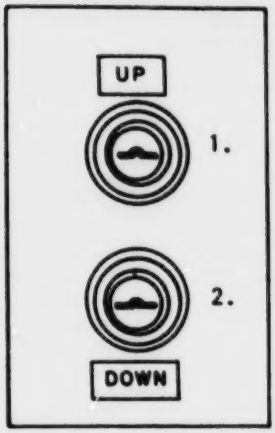
Activation of only one key is required to operate the lift. The key has been misplaced or unavailable in the past and it is now normally left in the switch on top of the drive unit. Since there are only nine steps between landings, the lift is usually brought to the appropriate landing by the operator using the control module instead of the call and send switches.

The carriage assembly travels at a nominal speed of 7.6 metres per minute. The travel time from landing to landing is approximately 25 seconds. The total trip time (from arrival at one landing to departure at the other landing in the presence of an attendant) is approximately 2 minutes.

(6) Safety

The lift platform is equipped with loading ramps for the upper and lower landings (see Photograph 2). The upper ramp is hinged but cannot be locked in the up position. On the platform at the ramp, a small raised lip extends the width of the platform and might restrain the wheelchair (if the brakes were disengaged and the wheelchair began to roll backwards). Cheney do not feel that a locking upper ramp is necessary since the leading edge of the ramp runs within 12 mm of the steps and the wheelchair would simply roll back against the stair riser. The lower ramp is a gravity self-locking type (see Photographs 2 and 6). When the wheelchair is placed on the platform, the safety bar is designed to position the wheelchair such that the passenger's feet will not be caught by the ramp when it hinges back upon arrival at the lower landing.

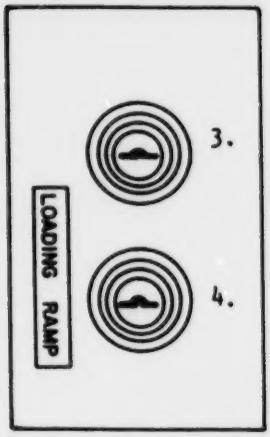
The Cheney lift is equipped with pressure sensitive switches on the platform which are intended to stop the lift during downward travel if the bottom of the platform contacts the floor (or any other obstruction). Both ramps are also equipped with terminal stopping switches which are intended to stop the lift at both ends of travel (or if the ramps contact an obstruction). During field visits to the Ottawa installation, the ramp terminal switches were not functional. There is no emergency "stop" switch for the passenger. However, it is possible that the passenger could deactivate the key switch, to stop the lift in an emergency, if the passenger were aware of the purpose of the key and also had the required mobility. The lift is linked to an audio alarm which functions when the lift is in operation.



UPPER CALL/SEND SWITCH (See photograph 7)

1. Call Switch; insert key and turn to right to call unit up. Constant pressure required.

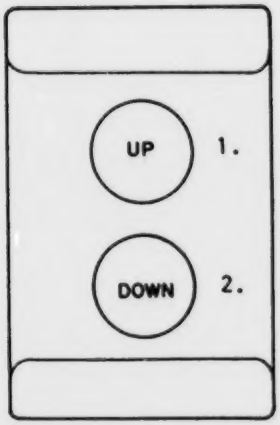
2. Send Switch; insert key and turn to right to send unit down. Constant pressure required.



LOWER CALL/SEND SWITCH (See photograph 8)

3. Call Switch; insert key and turn to right to call unit down, constant pressure required.

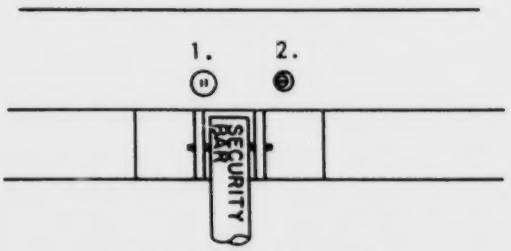
4. Send Switch; insert key and turn to right to send unit up. Constant pressure required.



CONTROL MODULE

1. Up Button; requires constant pressure.

2. Down Button; requires constant pressure



HANGER CONTROL

1. Socket for jack of control module.

2. Key Switch; insert key and turn clockwise to provide power for use of control module. (See Photograph 9)

FIGURE 2

CONTROLS OF CHENEY STAIRWAY LIFT III

The Cheney lift at the Ottawa Airport is equipped with a safety bar. This bar is not a Cheney component but was apparently installed at the insistance of the Chief Elevator Inspector, its purposes being to correctly position the wheelchair on the platform, to provide a secure handhold for the passenger and to prevent forward movement of the wheelchair.

The safety bar is held in the vertical position by a pin and stop arrangement at its pivot. In the vertical position, the bar protrudes past the corner of the wall as shown in Photograph 1. The lift has been operated in this configuration, in the past, and the safety bar has struck the wall. As a result, the hinge is in very poor condition and there is considerable forward/rearward play in the safety bar when it is deployed horizontally. Thus, the hinge assembly currently requires repair/redesign to ensure that the safety bar is relatively rigid when in use and that it will not strike the wall when the lift is operated with the bar in a vertical position.

The Cheney Wheelchair Lift III is available with a power folding option for loading either from the side or the two ends. In both cases the folding is accomplished by a linear actuator acting between the machine frame and the platform. Without the power folding option the vertical force required to fold the platform is 147 N.

Standard B355 requires an overspeed brake. The Cheney device currently does not have this feature but this feature will be inciuded by mid 1984 in order to bring the equipment into compliance with the new American National Standards Institute A17.1 Elevator Code. The revised version of the wheelchair lift section of this document will be in effect by early 1984.

(7) Maintenance

The maintenance records for the Cheney lift at the Ottawa Airport were reviewed. The records covered all maintenance work conducted in 1981 and 1982. During this period, the lift was serviced on eight occasions for a total service time of 30.5 hours. Other than routine maintenance and checks, work was carried out on the lower ramp hinge, the latch mechanism and the lower support rail.

If one assumes that the lift was out of service for a full day each time it was serviced, then the lift was available for use 99% of the time over the two year period. Thus, the lift appears to have a good record of reliability and has apparently required a minimum of maintenance over its five year period of operation. When purchased new, Cheney offer a one year warrantly on parts for the lift.

(8) Recommended Improvements

The Cheney lift at the Ottawa Airport has proven to be a very reliable and functional elevating device. Minor problems with the latch mechanism, the safety bar hinge and the inoperative ramp switches have been discussed and they all require attention. Without the power folding option the platform required a considerable effort to raise and lower it. It is possible that this problem could be partially resolved by means of a power assisted folding option (possibly utilizing a spring) at a lower cost than the linear actuator folding mechanism. When the lift is used in a residence (as is normally the case in the United States), the platform may be left unfolded permanently (at the lower landing) and this problem is not as significant as it is in the application at Ottawa Airport.

When the Cheney lift was installed, Standard B355 was not yet written. Thus the Cheney lift is not required to comply with Standard B355. Current areas of non-compliance include rated load, overspeed brake, locking ramps and a mechanism with

which to lower the lift in the event of a power failure. However, as noted, Cheney have indicated that they will be making modifications to the Wheelchair Lift III to conform with the revised U.S. code (similar to Standard B355) to be introduced in 1984. These modifications, while not enabling complete compliance with Standard B355, leave only two areas (rated load and loading ramps) to be addressed to comply fully.

2.3 Ergonomic Evaluation

(1) Task Analysis

(a) General

Results of the task analysis for operations involved in taking a passenger to the loading bridge (and, hence, in mounting the stairway) are set out in detail in Table 1. Since operations for the down-the-stairway task are mainly merely the reverse of those in Table 1, they are omitted. In this table, the abbreviation "w/c" stands for "wheelchair". Under the Comments/Difficulties column, reference is made wherever possible to photographs which are to be found in the Appendix. These photographs should greatly assist the reader in understanding the ergonomics of the relevant operations.

(b) Summary and Recommendations

The operational task for the Cheney Lift consists of numerous small operations which must be carried out in correct sequence. Together they constitute a dull routinized task which places a considerable load on memory and is tedious to perform. Simplification of procedures as well as of system design is recommended. In particular, a conveniently located storage place should be provided for the module and switch key to reduce load on memory and, as well, to reduce possibility of loss or vandalism.

The task also entails frequent adoption of awkward bending and twisting movements of the body, sometimes under heavy physical load which, as a consequence, is distributed asymmetrically over the body. As a result, the operator is at risk of damage of tendons, muscles, ligaments, and joints in the shoulder, back, and lower limbs. The following recommendations are relevant:

- Assign to the passenger, whenever possible, the responsibility of braking and unbraking the wheelchair and of wheeling it on and off the platform. These procedures would tend not only to reduce physical stress to the operator's musculo-skeletal system, but also to offset any sense of loss of control wheelchair occupants are subject to when officials (no matter how necessarily) take over their logistic requirements. When the passenger is unable to take this responsibility, braking and unbraking should be performed from the rear.
- Modify system design to include self-locking power folding and unfolding. Operators should meanwhile be encouraged to bend the knees (if possible) when raising and lowering the lift, and to adopt positions which tend to distribute the load as equally as possible on both sides of the body.
- Install a safety bar at both front and back ends of the platform to avoid the awkward manoeuver of backing the wheelchair onto the platform when preparing to ascend.
- Automate the safety bar lowering and raising operations, with control effected through the lift control module.
- Consider installation of separate START and STOP touch-sensitive buttons on lift control module to eliminate need for constant pressure. Otherwise, ensure that the pressure required on the existing button to maintain movement of the lift is light enough to avoid stress to the blood vessels in the finger tip, or to the inter-phalangeal joint.

TABLE 1
Task Analysis: Cheney Stairway Lift III, Ottawa

Operations	Comments/Difficulties	Comments/Solutions
To plane loading bridge		
A - Prepare to load w/c on lift		
1 - brake w/c	- adopted as passenger-handling safety measure - requires leaning twisting movement, incurring stress to spine; and body contact and invasion of passenger's personal space if done from front	- assign responsibility of braking and unbraking to passenger whenever possible - or perform from rear whenever possible
2 - release catch mechanism holding lift in position	- mechanism on stair-side of lift - requires releasing catch with left hand while holding lift with right - awkward (see Photograph 10)	- self-locking power folding advised
3 - grab handle and lower platform to horizontal position	- handle at far left - operator at mechanical disadvantage with one foot on stair - adverse body positions prevent symmetrical distribution of physical load, and incur stress to spine, limbs, shoulder (see Photographs 11, 12 and 13)	- self-locking power folding advised
B - Load w/c		
1 - release w/c brakes	- as for A-1	- as for A-1
2 - turn chair around and back onto platform	- backward entry necessary to take advantage of safety bar - awkward manoeuver - operator must back onto stairway to accomplish (see Photographs 14 and 15)	- install safety bar at both ends of platform
3 - brake w/c	- must be done from front - thus problems as for A-1	- assign task to passenger if at all possible
4 - pull locking pin out to release safety bar	- entails twisting movement to avoid moving into passenger's space (see Photograph 16)	- automate safety bar operation with control through lift control module
5 - lower safety bar	- accomplish with left hand - problem mainly for passenger with high chair, as bar rests on knees	- safety bar should be designed to accommodate chairs of all heights

(Continued)

TABLE 1
Task Analysis: Cheney Stairway Lift III, Ottawa

(Continued)

Operations	Comments/Difficulties	Comments/Solutions
C - Ascend stairway		
1 - pick up control module and turn on key	- module left on top of lift with key in switch to avoid misplacing - arrangement leaves system open to vandalism (see Photographs 19 and 20) - module preferred to key-operated send and call switches (see Photographs 6 and 1 respectively) because operator can start and stop motion at will	- storage space necessary for module and switch key
2 - position self to side of passenger and press UP button	- pressure must be maintained until platform reaches top, unless a midway stop is desired	- separate START and STOP buttons might be preferable to present single constant pressure type
3 - advance up stairs sideways alongside passenger	- operation boring as lift moves slowly - module cord must be kep from dragging (see Photographs 21 and 22)	- operator would be more comfortable standing on platform with passenger
4 - remove finger from UP button when lift reaches top	- lift stops automatically on reaching top (or bottom), thereby avoiding need for control action by operator	- this feature is satisfactory
D - Unload w/c		
1 - place control module on top of lift	- operator must remember to leave module in the same place	- as for C-1
2 - release w/c brakes	- must be done from rear at this point, but bending/twisting movement still required (for 4th time)	- as for B-3
3 - pull chair backwards off platform, turn around, and wheel passenger to loading bridge	- a relatively easy manoeuver provided chair is in good condition	- none

(Continued)

TABLE I
Task Analysis: Cheney Stairway Lift III, Ottawa
(Continued)

Operations	Comments/Difficulties	Comments/Solutions
E - Replace lift (on way back from loading bridge)		
1 - pick up module from platform and press DOWN button	- operator must remember to return lift at bottom of stairway, or leave at top if incoming passengers expected	- various design modifications are needed to simplify task elements
2 - descend stairway alongside empty lift	- operation boring as movement slow	- as for C-3
3 - remove finger from button when lift reaches bottom	- as for C-4	- as for C-4
4 - place control module on top of lift and turn switch key to OFF position	- as for C-1	- as for C-1
5 - lift safety bar to vertical position	- body symmetry can be maintained for operation, as w/c now absent	- none
6 - secure safety bar with locking pin	- awkward - safety bar held with one hand while locking pin inserted with other	- as for B-4
7 - grab platform handle and raise platform to vertical position	- considerable physical load again placed on operator while in adverse position - vertical lift force = 147N (see Photograph 13)	- as for A-3
8 - insert locking pin to secure, letting safety flap fall down to secure pin	- awkward and physically loading - operator must support platform with one hand and insert pin with other	- as for A-3

(2) Passenger Evaluation

(a) Observations

In general, volunteer passengers found little problem with the Cheney Lift at Ottawa International Airport. As the area in which the lift is located is closed off from the main lines of traffic, the wheelchair occupant is not greatly exposed to observation by other passengers; thus he or she can be transported in the lift without feeling too conspicuous. In any case, as there are only nine steps to negotiate, the trip is quickly completed. Additionally, the smooth ride quality of the lift minimizes physical discomfort and (along with the safety bar) encourages a feeling of confidence in the mechanism.

Still, some problems manifested themselves during the study. First, the need for the attendant to lean over the passenger to brake and unbrake the wheelchair (an operation occurring four times during one ascent or one descent) has potential for incurring body contact or even just intrusion of personal space unwanted by either passenger or attendant. In any case, this operation may reinforce any sense of loss of control or independence experienced by the passenger placed in the care of an attendant. Note the tendency for the passenger in Photographs 14, 15, 17, 23 and 24 to operate the chair herself. Responses of this kind are understandable when it is considered that one preparing to spend a lifetime in a wheelchair undergoes rehabilitation aimed at making him or her as independent as possible.

In addition, it may be uncomfortable for passengers to go upstairs in the backward-facing position which must be adopted because of the location of the safety bar, as they generally expressed a preference for facing in the direction of travel. The lift ascending with the passenger facing in the direction of travel is shown in Photograph 27; note the security bar cannot be lowered. The sense of security afforded the passenger by the addition of the safety bar may be offset by its shaky state of securement, as well as by possible annoyance for those in chairs so high that the bar must rest on the knees. In the former case, loss of confidence regarding the properties of the safety bar may generalize to the system as a whole.

Depth perception from the top of the stairway may elicit avoidance reactions in some passengers arriving by plane and about to use the lift for the first time. Certainly anxiety appears to be exhibited by the passenger in Photograph 25, who has just started the descent. However, as there is jerk on startup of the lift, this expression could also be due to momentary fear of system failure.

Finally, a minor irritation may arise when the module cord is inadvertently dragged across the passenger's knees (see Photograph 26).

(b) Summary and Recommendations

The following recommendations are put forth suggestively as means of reducing any psychological or physical discomfort which may be experienced by users of the Cheney Lift:

- Assign responsibility of braking and unbraking the wheelchair and, if possible, of wheeling on and off the lift, to the passenger. As mentioned earlier, these procedures will tend to reduce feelings of loss of independence and encourage a sense of sharing in the task.

- Redesign safety bar to accommodate chairs of all heights, and install front and back to eliminate need for backward facing ascent.

- Secure bar hinge mechanism to maintain passenger's confidence in the system.

- Redesign system, if possible, so as to eliminate jerk on startup and, hence, passenger fear reactions.

- Allay feelings of anxiety, due to depth perception, startup jerk, or other features of the system, by assuring the passenger of the safety of the system and advising him/her beforehand of what to expect. However, a paternalistic or authoritarian attitude toward the passenger should be avoided.

2.4 Economic Evaluation

An alternative to the use of the stairway lift at Gate 26 at Ottawa International Airport requires additional manpower and effort, and is generally demeaning for the wheelchair passenger. The most likely alternatives to the use of the stairway lift are either to manually carry the wheelchair plus passenger up the stairs or to use the airport ancillary vehicles to assist in putting the wheelchair passengers on board. The economic cost is by no means the only consideration that should be addressed in questioning the suitability of the stairway lift. The feelings of the passenger must be given due consideration, and it is important that where at all feasible, all passengers should utilize the same general facilities. The stairway lift eliminates the need to 'segregate' disabled passengers from all others for the purpose of boarding the aircraft.

The average selling price of the Cheney Wheelchair Lift III is somewhere between $9,700 and $10,500 U.S. per unit, the variation reflecting any special wall support if required. There is a 10% duty imposed on the unit and a brokerage charge of approximately $75. The above price includes charges for travel, labour, freight, CSA approved electrical system and normal distributor mark-up.

Maintenance costs for lift are minimal and for a two year period the lift availability was in excess of 99%.

It is suggested that the Cheney Wheelchair Lift is good value at the price quoted. The device is solid and reliable and, if treated without abuse, should provide many years of trustworthy service.

3. The Garaventa Stairway Lift

3.1 General

The Garaventa wheelchair lift is designed as both a retrofit and original installation stairway lift device to provide access for disabled persons in public and private buildings. The lift is unique in being capable of carrying a person in a wheelchair up and around corners stopping at intermediate landings if required, without transfer.

The Garaventa wheelchair stairlift was designed in 1976-1977 in Switzerland to fill a requirement which the inventor himself had experienced when attempting, with difficulty, to install other commercially available wheelchair lifts into private and public buildings. Many buildings have simple and complex curvatures, and problems are commonly compounded by the narrow width of staircases.

Production of the stairlift commenced in Switzerland in 1977 and more recently in West Germany. In excess of two hundred units are produced per year. Garaventa (Canada) Ltd., 7505 134A Street, Surrey, B.C. V3W 7B3 (Tel: 604-594-0422) own the patent, manufacturing and distribution rights for the lift in Canada and the United States. They commenced production at their plant near Vancouver in 1979. Since that time approximately one hundred units have been installed in Canada and approximately three hundred in the United States.

Most installations are in public buildings, typically schools, universities, offices, recreation centres and churches. In Canada there are five devices in operation in transportation terminals, one at Halifax International Airport, two at Kingston (Ontario) VIA Rail Station and one each at St. John's Airport and the Port-aux-Basques CN Marine Terminal.

3.2 Engineering Evaluation

(1) General

A Garaventa stairway lift is installed at the Halifax International Airport. The device was installed in 1981 and is located adjacent to Gate 22. The lift is situated in a stairwell which has 24 risers (and an intermediate landing) with a total level change of approximately 4.3 metres. The lift runway is not fully guarded and the device is therefore classified as a Type D installation.

Two Garaventa lifts are installed at the Kingston Railway Station. The devices were installed in 1982 and are located in the stairwells leading to and from an underground tunnel which provides access between the main station and the eastbound loading platform. Both stairwells have 23 risers (and an intermediate landing) with a total level change of approximately 4.1 metres. The stairwell adjacent to the main station is straight while the stairwell near the eastbound platform has a 90° bend at the intermediate landing. When the lifts are in operation, the runways are fully guarded and the two devices are therefore considered to be Type C installations.

The model type for the above installations is a Garaventa Wheelchair Stairlift. The device is shown in its folded and unfolded configurations in Photographs 28 and 29. The two lifts at Kingston are equipped with the optional folding seat (and seat belt) which can be seen in Photograph 29 with the seat and arm rests folded.

(2) Lift System

The Garaventa stairway lift is shown schematically in Figure 3. A sketch of the Garaventa carriage assembly is shown in Figure 4. The system consists of a carriage assembly (containing the folded platform and optional folding seat) supported on two parallel tubes inside which runs a steel haul cable, attached to the carriage. A mechanical drive unit is located at the upstairs end of the tubes and an overspeed governor (arrestor) is located at the downstairs end. By bending the tubes in three dimensions, the lift can be tailored to an infinite number of differently shaped and sized stairways.

The tubes are made of mild steel and are parallel except where they approach and terminate at the drive (see Photographs 28 and 29). They are about 500 and 1100 mm above stair height (varying slightly according to the slope of the stairway). The upper tube commonly also serves as a handrail. The upper tube is slotted underneath for most of its length for attachment to the cable of the carriage connecting levers. The lower tube is not slotted. The upper tube carries all the vertical weight of the carriage assembly and provides it with lateral stability in conjunction with the lower tube which carries no vertical weight (see Figure 4).

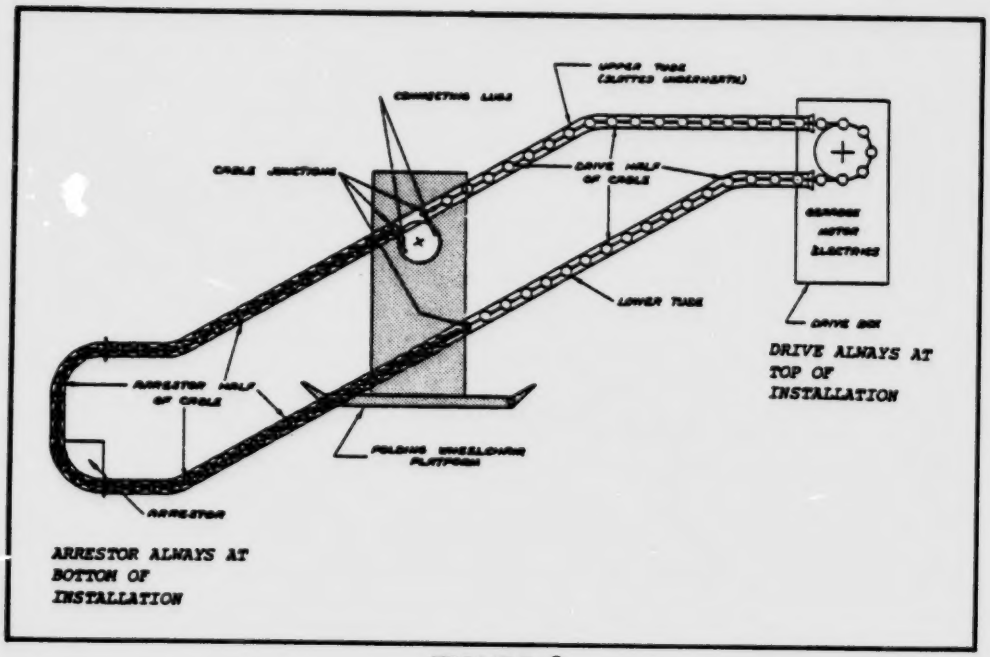


FIGURE 3

SCHEMATIC OF GARAVENTA STAIRWAY LIFT

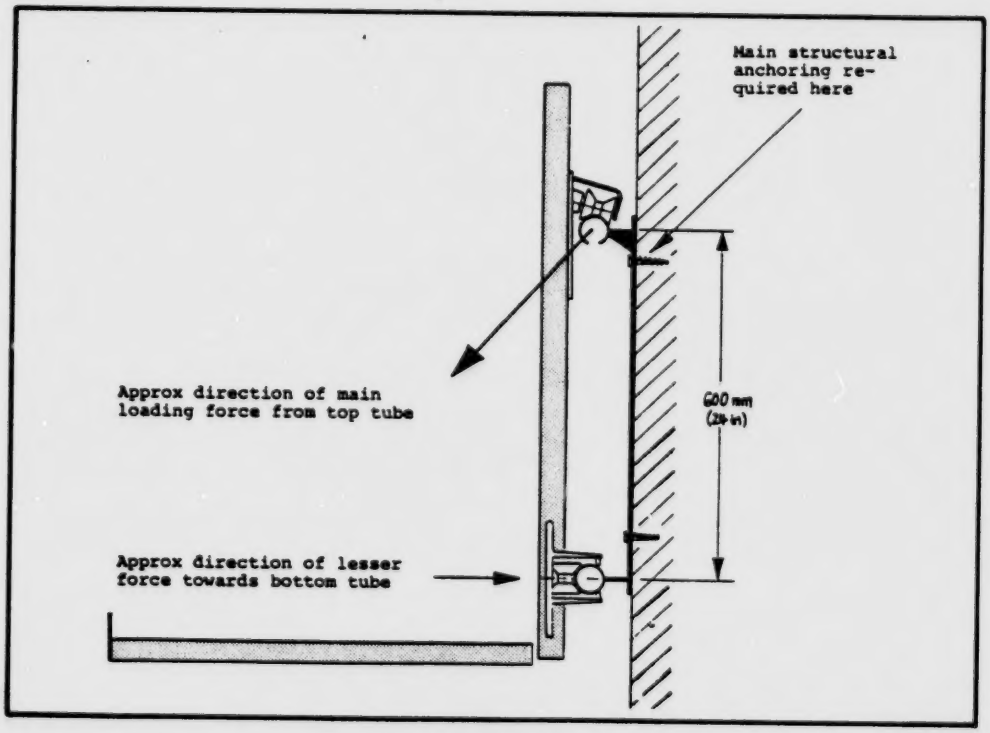


FIGURE 4

SKETCH OF GARAVENTA CARRIAGE ASSEMBLY

The tubes are always 600 mm apart (measured vertically) and are maintained at this distance by vertical spacing struts (see Photographs 30 and 31) welded at maximum one metre slope intervals. The spacing struts are attached to the wall by various means depending upon the construction details of the supporting wall. At Halifax and Kingston, the spacing struts are bolted directly to a concrete block or poured concrete wall (see Photographs 30 and 31).

The Garaventa lift requires a minimum stairway width of 970 mm for a straight stairway and 1070 mm for a turning stairway. Due to the large number of lift layouts possible with the Garaventa system, it is difficult to specify the various clearances required for the device at the upper and lower landings. However, at the lower landing, approximately 2500 mm is required for a front loading platform. A minimum stair to ceiling overhead clearance of 1830 mm (for a typical stairway angle of 35°) is required.

Where there is an intermediate landing, two options exist, as shown in Photographs 30 and 31. The lift may level out over the landing prior to following the slope of the stairs (Photograph 30) or the angle of descent/ascent may be modified to incorporate the additional distance of the landing (Photograph 31).

(3) Platform

The platform can be folded to a vertical stored position (see Photograph 28) to within 250 mm of the attachment wall. The lift is normally stored at the upper landing. At Kingston, a lock (visible in upper left of Photograph 29) is used to secure the platform when folded and thereby prevent unauthorized deployment of the platform. A minimal effort is required to raise or lower the platform. However, Garaventa have recently introduced a power-folding, self-locking platform and this platform is to be installed on the Halifax lift in the near future.

The platform is equipped with a pair of hinged ramps which are raised and lowered by levers located either on the upper part of the hanger or above the hanger unit. Photograph 32 shows the lever for the upper ramp pulled out to allow the wheelchair egress from the platform. Photograph 33 shows the same lever pulled to lower the ramp, permitting access to the platform. These two photographs are for the Kingston installation.

The current lift at Halifax Airport is equipped with ramp activating handles protruding from the top of the hanger unit. See Photograph 34. the top landing ramp is shown in the lowered position, and the handle pulled down to the side of the hanger unit, in Photograph 35.

The standard Garaventa platform is 715 mm wide and 900 mm long (exclusive of the two ramps which add an extra 200 mm to the overall length). This platform size is large enough to accommodate most wheelchairs, although larger platform sizes are available to customer specifications. At Kingston, both the operator and users commented that the platform should be approximately 150 mm longer. Problems have been experienced with oversized wheelchairs (and sometimes with normal wheelchairs) contacting the ramps and stopping the lift between landings.

The rated load of the Garaventa lift is 200 kg which exceeds the minimum rated load of 185 kg specified in Standard B355. During user evaluations at Kingston, the outside edge of the platform deflected by approximately 16 mm when the platform was occupied by a passenger and wheelchair with a total weight of approximately 130 kg. This deflection caused the lift to stop prematurely while approaching the lower landing. The lift stopped because the pressure sensitive cut-out switches (described later) on the underside of the platform had sensed contact with the landing. However, the limit switch, which permits the lower ramp to be folded down, had not been contacted. In order to fold down the ramp, the attendant had to manually raise the platform by holding the handle on the outside edge and pulling upward. This released the pressure sensitive switch and allowed the lift to descend the extra distance required to activate the limit switch.

(4) Drive Mechanism

The haul cable forms a continuous tensioned loop within the tubes and is composed of two halves (see Figure 3). The drive half has nylon balls crimped on at regular intervals which positively engage in the drive cog. The arrestor half has nylon segments touching each other which perform a governing function in the event of overspeed. The cable travels up and down, not in a circular motion, so that the drive half never enters the arrestor and vice versa. The cable in tensioned at the drive.

The drive unit (see Photograph 36) is always located upstairs. It consists of a 746 W electric brake motor which drives a self-locking worm gear through a toothed belt drive. A drive wheel fixed to the gearbox positively engages a minimum of three nylon insulating balls in the drive half of the cable.

If electric current is switched off, either automatically by the landing switches, or with the normal or emergency switches, or in the event of a power failure, the brake in the motor automatically applies and stops the carriage. The self-locking nature of the worm gearing also prevents the gearing turning under the weight of the carriage. Thus there is always a second level of safety in the event of failure of the motor brake or drive belt.

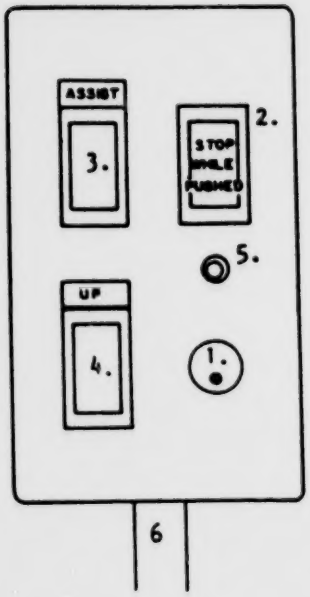
In the event of a power failure, a hand crank is provided (inside the drive unit box) with protection against inadvertent power return when it is in use. The drive box is normally locked and, during both field visits to the Kingston installation, the attendant did not have the key to open the box.

The arrestor (see Figure 3) is always located downstairs. The arrestor functions in the event of carriage overspeed due to cable breakage or other cause. A mechanical device jams the nylon segments which, touching each other in this half of the cable and confined by the tube, form a solid incompressible column and support the weight of the carriage above.

(5) Operation

The lifts both in Kingston and Halifax are intended to be operated principally by an attendant, an employee of VIA Rail or the airline. The design of the Garaventa lift is such that there is generally an option available to operate the lift by means of the hand held control module or by the toggle switch on top of the hanger. These two options exist in the Halifax installation but, on the Kingston lifts, the toggle switch on the hanger has been removed and thus this option does not exist.

The controls at Kingston are as indicated in Figure 5.



UPPER CALL PANEL
(See photograph 37)

1. Master Power Switch; use key to turn on power (clockwise), remove key.

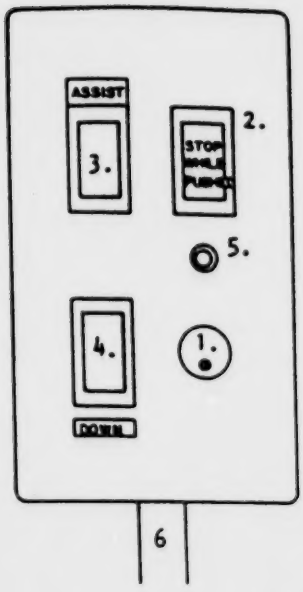
2. Emergency Stop Switch; press top portion of switch inward.

3. Attendant Call Button; press inward (not operational at this site).

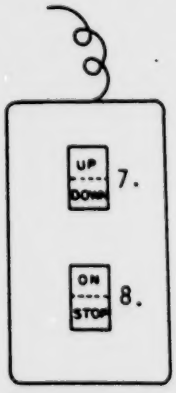
4. Lift Call Switch; used to call lift up from lower landing or down from upper landing. Requires constant pressure. Can only be used when (1) is on.

5. Indicator Light; shows power is on.

6. Power Conduit.



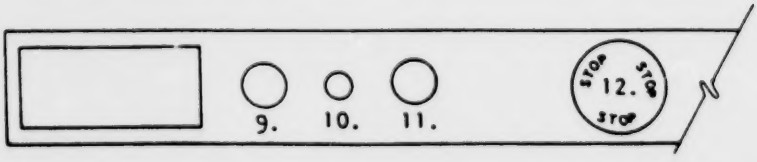
LOWER CALL PANEL
(See photograph 38)



CONTROL MODULE

7. Control Switch; requires constant pressure, either on upper portion for 'up' or lower portion for 'down'.

8. Starter Switch; must be pushed downward to the 'ON' position before lift will operate.



HANGER CONTROLS
(See photograph 39)

9. ON/OFF key; insert key, turn clockwise, leave in place.

10. Socket for jack of Control Module.

11. Plate over position for Toggle Switch.

12. Emergency Stop Button; push down; will remain down until turned ¼ turn clockwise.

FIGURE 5

CONTROLS FOR GARAVENTA LIFT (KINGSTON)

(a) Upper Call Panel (see Photograph 37) consists of: keyed switch, indicator light, emergency switch, attendant call switch and lift call switch. The master key on/off switch turns on the power to the unit. When power is on the red light above it is illuminated. This emergency switch is a rocker switch which, when pressed, cuts power off from the unit. The switch in the upper left is the attendant call switch which activates an audible signal in the station attendant's area, and is used to indicate that assistance is required. The lower left switch, a spring return lever switch, is for calling the unit up to the top landing from the lower landing.

(b) The Lower Call Panel (see Photograph 38) is identical except that the call switch is for bringing the unit down from the upper landing.

(c) The Control Module is a hand-held two-switch unit. The lower switch is an ON/OFF switch that must be in the ON position before the upper switch (UP/DOWN) can be activated. This latter switch requires constant pressure.

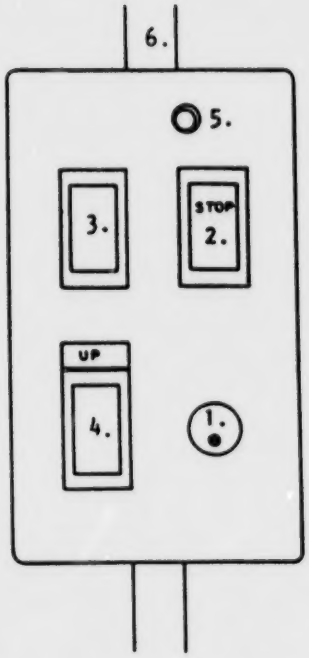
(d) The Hanger Controls (see Photograph 39) consist of the following, from left to right: on/off key switch; socket for jack of control module; plate covering the position of the manual control switch; and the emergency stop button.

The on/off key control requires insertion of the key and it is to be turned clockwise to activate the unit. The key must remain inserted in the switch. The control module socket receives the jack on the control module cord. The manual control toggle is not used in this left installation and this control is by means of the module. The emergency button, when pressed down, stops movement of the lift by cutting off the power supply. The button must be turned counterclockwise to reset.

(e) There is a Master Control Panel attached to the drive unit on the top landing. This unit is shown in Photograph 40. There is a START and a STOP button. For the unit to be utilized the START button must be pressed inward. The unit can be stopped at any time by pressing the STOP button, or alternatively by closing the switch cover. The cover has a protrusion that activates the STOP button thus preventing use of the unit.

The controls at Halifax are as indicated in Figure 6.

(a) Upper Call Panel (see Photograph 41) consists of: keyed switch, indicator light, emergency switch, attendant call switch (not connected) and lift call switch. The master key is to be inserted and turned counterclockwise to turn on power, and withdrawn. When power is on the small red light (top and right of centre) will be illuminated. Originally the switch at top right became illuminated when power was on but this was modified by installing separate light due to problems when the light burnt out and no power was available to the lift. Emergency stop switch (top right): this red switch will cut power to the lift when the upper part (marked STOP) is pressed in. Attendant Call Switch (top left): this feature is not operational at this installation. Lift Call Switch (lower left): this toggle type switch will call up the lift from the lower landing if the power is turned on and constant pressure is applied to the switch in the upward direction.



1. Master Power Switch; use key to turn on power (clockwise), remove key.

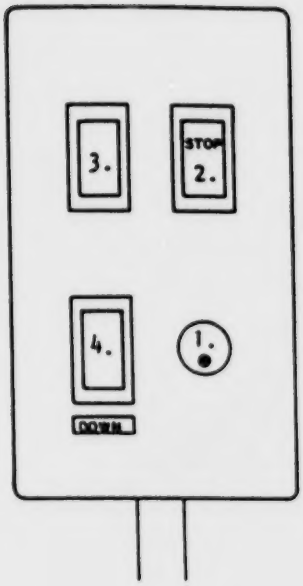
2. Emergency Stop Switch; press top portion of switch inward.

3. Attendant Call Button; press inward, rings bell.

4. Lift Call Switch; used to call lift up from lower landing or down from upper landing. Requires constant pressure. Can only be used when (1) is on.

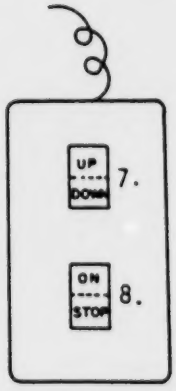
5. Indicator Light; shows power is on. In Lower Call Panel, Switch 2 is illuminated when power is on.

6. Conduit to light and buzzer.



UPPER CALL PANEL
(See photograph 41)

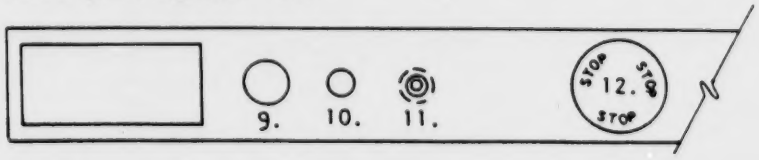
LOWER CALL PANEL
(See photograph 42)



7. Control Switch; requires constant pressure, either on upper portion for 'up' or lower portion for 'down'.

8. Starter Switch; must be pushed downward to the 'ON' position before lift will operate.

CONTROL MODULE
(See photograph 43)



HANGER CONTROLS
(See photograph 44)

9. ON/OFF key; insert key, turn clockwise, leave in place.

10. Socket for jack of Control Module.

11. Toggle Switch; moves left (down) or right (up); requires constant pressure.

12. Emergency Stop Button; push down; will remain down until turned ¼ turn clockwise.

FIGURE 6

CONTROLS FOR GARAVENTA LIFT (HALIFAX)

(b) Lower Call Panel (see Photograph 42) consists of: identical elements to the Upper Call Panel except that the emergency STOP switch becomes illuminated when power is ON, as no separate light has been added. Also the Lift Call Switch is for calling the lift down from the upper landing. This requires constant pressure in the downward direction.

(c) Control Module (see Photograph 43) is a hand held unit with two switches. The lower switch (red) is marked ON at the top, and STOP at the bottom. This switch must be in the ON position for the lift to be controlled by the hand module. The upper switch (green) is marked UP at the top and DOWN at the bottom. This switch controls the direction of movement of the lift when being controlled by the module, and requires constant pressure on the switch.

(d) Hanger Controls (see Photograph 44) consist of an on/off key, the module socket, the control toggle and an emergency STOP button. The key must be inserted into the socket and turned clockwise to provide power. The key is left in position. The control module jack is inserted into the socket when control is to be by means of the module. Insertion of the jack bypasses power to the toggle switch which thus cannot be used when the control module is plugged in. The control toggle enables the wheelchair passenger to operate the lift as long as the control module jack is not inserted and all power switches are ON. The thin metal toggle switch is pushed to the left for DOWN and to the right for UP. Constant pressure is required. The emergency STOP button, when hit from above and pushed downward, cuts power to the lift. To release the button, and resume power flow, the button must be turned about one quarter of a revolution counterclockwise and it will spring up.

Note: The recently added power lift feature is controlled by a switch on the end of the ramp control levers. The original ramp control levers which were pulled in a quarter-circle movement from above the hanger have been replaced by a sliding bar, at each end of which is located the power fold switch (see Photograph 45).

The attendant walks either in front of or behind the lift during its travel from one landing to the other (see Photographs 46 and 47).

The carriage assembly travels at a nominal speed of 6 metres per minute. At Kingston, the travel time from landing to landing is approximately 1 1/2 minutes. The total trip time (from arrival at one upper landing to departure from the other upper landing, in the presence of an attendant) is approximately 4 to 5 minutes. At Halifax, the travel time is very similar but the total trip time is less due to the absence of safety barriers and padlocks.

(6) Safety

The lift platform is equipped with locking loading ramps for the upper and lower landings. In between landings, these ramps are mechanically locked in the up position. Limit switches automatically stop the lift at each landing. While at a landing, the ramp not in use is locked in the up position.

The platform ramps and the lower surface of the platform are equipped with pressure sensitive cut-out switches. Should any of these switches encounter an obstruction on the stairway, the lift will stop. If the wheelchair moves excessively on the platform and touches a ramp while in motion, the lift will stop. There is a cut-out switch in the

drive to detect an undertensioned cable and another in the arrestor which operates in conjunction with the mechanical stop mechanism.

Emergency stop buttons are installed at each landing, on the hanger and on the control module. The hanger and module controls override the controls at the landing call stations. At both Halifax and Kingston, audio alarms are installed. In addition, at Kingston, there are safety barriers and lights at all landings (see Photographs 48 and 32). The lifts at Kingston are equipped with the optional folding seat for use by ambulatory passengers. The seat incorporates folding arm rests along with a pelvic lap belt (see Photograph 49).

(7) Maintenance

The maintenance records for the Garaventa lifts at the Kingston Railway Station were not available. However, the maintenance records for the lift at Halifax were reviewed and it is assumed that the maintenance records of the Kingston lifts would be similar.

The Halifax lift was installed in December, 1981. The maintenance records covered the period from April, 1982 to June, 1983. During this period, there were 15 service calls for a total service time of 34.0 hours. There were eight service calls for electrical work (19.5 hours) and seven for mechanical work (14.5 hours).

If one assumes that the lift was out of service for a full day each time it was serviced, then the lift was available for use a minimum of 95% of the time over the 14 month period. In fact, since most of the repairs were minor, the lift may actually have been available for use closer to 98% or 99% of the time. Many of the calls were related to the lift being new and it does appear to have a good record of reliability.

(8) Recommended Improvements

The Garaventa lifts installed at Halifax and Kingston have proven to be reliable and functional elevating devices. The platform is considered to be slightly too short by the operators. However, larger sized platforms are available from Garaventa.

During user evaluations at Kingston, the electric control signal was momentarily interrupted which caused the lift to stop and start as the signal was lost and then regained. The attendant stated that this was the first time that this phenomenon had occurred. The passenger was not placed in any jeopardy, however, it was bothersome. Garaventa was contacted and they felt that the problem was likely due to contamination of the sliding contacts where the carriage attaches to the upper tube. Regular inspection and cleaning of these contacts would solve the problem.

The problem with the deflected platform causing the lift to stop prematurely (described in detail in Section (3), Platform) must be addressed. It can be solved by adjusting the terminal switch. However, the amount of deflection (16 mm) appears to exceed that permitted by CSA Standard B355. Clause 6.3.1.1 of the standard states that "Vertical deflection of the platform, when the rated load is equally distributed on any 25% of the platform area, shall not exceed 5 mm/1000 mm of platform length".

Garaventa claim that their lift complies fully with Standard B355. They interpret Clause 6.3.1.1 as a specification related strictly to deflection of the platform itself and not including any deflection due to tilt of the whole carriage assembly. Representatives of both CSA and the Ontario Ministry of Consumer and Commercial Relations were contacted and they agreed that the clause is ambiguous. If Garaventa's interpretation is correct, then their lift complies with the standard. If platform deflection includes deflection due to the tilt of the entire carriage, then it would be

very difficult to design a stairway lift that is unsupported on one side, such as the Cheney and Garaventa lifts, which could comply with the clause. This ambiguity is currently being considered and may be clarified in the near future.

3.3 Ergonomic Evaluation

(1) Task Analysis

(a) General

Installations of the Garaventa lifts at Kingston and Halifax entail very similar operating procedures; therefore results of the relevant task analyses are presented in combined form in Table 2. Combining results in this way required that the from-vehicle-to-terminal task be represented in the table, since the Garaventa is used at Halifax only to get incoming international wheelchair passengers from the aircraft through Gate 22 to Customs. At this site, only a down-the-stairway task is involved. However, at Kingston, the passageway connecting the platform to the terminal is built underneath the railway tracks; therefore, regardless of whether the passenger is being taken to or from the train, the task involves descent of one stairway followed by ascent of a second one. As the descending task is common to both sites, this one was chosen for presentation in Table 2. Since two separate lifts were installed at Kingston to overcome the level changes there, the operator's task is doubled each way. However, as operations for the ascent are virtually the reverse of those for the descent, they could be safely omitted from Table 2.

As in Table 1, "w/c" in Table 2 is an abbreviation for "wheelchair" and, again, reference is frequently made in this table to photographs to be found in the Appendix in order to assist the reader in understanding various ergonomic considerations.

(b) Summary and Recommendations

The operational task for the Garaventa lift is even more tedious and memory-loading than that for the Cheney lift, especially at Kingston where the installation of two lifts doubles the number of task elements on each trip. This system involves four different arrays of controls, namely, that on the control module, and those on the master-switch, call/send, and hanger panels. Hence the operator is under heavy mental load in trying to work with a non-integrated control system which requires attention to numerous small operations, their nature, and the sequence in which they are to be performed, as well as to the location of the various detached components. Operators at Halifax understandably reported that the task is so tedious and time-consuming that they would prefer to take passengers through an alternate route which, unfortunately, is outside the security area. Their counterparts at Kingston, for whom task elements are twice as great, have no other alternative for those passengers who cannot walk on their own. It is strongly advised, then, that everything possible be done to simplify the operator's task. The following recommendations are made:

- Adjust circuitry to integrate control system, reducing the number of control panels as well as the number of operations required. Computer techniques might be possible.

- Standardize controls both within and between systems. In the former case, movements of all switches and knobs should consistently accord with the population stereotypes for such movements (e.g. clockwise = down). In the latter case, differences in the ramp lowering and raising levers at Kingston and Halifax are noted. It is likely that one is more efficient than the other; therefore the more efficient model should be used on both. Any redesign of the control system should proceed with aid of qualified ergonomic expertise.

TABLE 2
Task Analysis: Garaventa Lifts, Halifax; Kingston

Operations	Comments/Difficulties	Comments/Solutions
From vehicle to terminal		
A - Prepare to load w/c on lift		
1 - brake w/c	- passenger-handling safety procedure - requires leaning twisting movement, incurring stress to spine; also body contact and invasion of passenger's personal space if done from front - risk of tripping on power cables (see Photograph 50, Kingston)	- assign responsibility of braking and unbraking to passenger whenever possible - otherwise, perform from rear if possible
2 - get control module and power key from wall-cabinet to right of unit	- relevant only to Halifax (at Kingston, module left on top of unit; key kept in operator's pocket)	- storage space at Kingston for module and power key required
3 - insert power key into latch on call station panel, and turn clockwise	- turns on power and activates visual and auditory warning stimuli - at Kingston, also lowers striped gates at top and bottom of stairs - one of many routinized operations in task (see Photograph 51, Kingston)	- task needs simplification - modification to circuitry suggested
4 - insert key into padlock on lift handle and turn to release	- relevant only to Kingston - padlock prevents vandalism - operation adds to information load - additional key to be kept in pocket (see Photograph 52)	- self-locking system recommended
5 - grab platform handle and lower into horizontal position	- handle located on far side of platform - equal distribution of load prevented - adverse movements entailed (although load not as great as for Cheney) (see Photographs 53 and 54)	- self-locking power folding system preferable
6 - pull right hand lever on side of hanger to lower access ramp	- at Halifax, clockwise motion compatible with downward motion of ramp and at Kingston, outward motion compatible with downward motion of ramp - note Kingston/Halifax differences in type of control in Photographs 55 and 56, respectively	- standardization of control panel features preferable

(Continued)

TABLE 2
Task Analysis: Garaventa Lifts, Halifax; Kingston

(Continued)

Operations	Comments/Difficulties	Comments/Solutions
B - Load w/c		
1 - release w/c brakes	- as for A-1	- as for A-1
2 - push w/c forward onto platform	- see Photograph 57	- assign responsibility to passenger whenever possible
3 - brakes w/c	- as for A-1 (see Photograph 58)	- as for A-1
4 - push right hand lever on hanger to raise access ramp	- when raised, ramp acts as rear guard - at Halifax, counter-clockwise motion compatible with upward motion of ramp - at Kingston, inward motion compatible with upward motion of ramp	- none
C - Descend stairway		
1 - insert and turn key and insert control module jack into outlet on control panel on top of hanger	- operator must reach over passenger from back of chair (see Photograph 59)	- design of operational system needs extensive modification
2 - position self beside or behind passenger, with control module cord behind passenger	- at Halifax, operator must stand on other side of a railing in the middle of the stairway, or behind passenger (see Photograph 46)	- an insurmountable problem
3 - depress ON button on control module	- unnecessary operation	- as for A-3
4 - depress DOWN button to activate descent of lift	- requires constant pressure - stress to blood vessels and finger and to interphalangeal joint may occur	- separate START and STOP buttons may be preferable
5 - pace descent down the stairs with that of lift	- descent of unit is slow - therefore task is boring, and time-consuming	- variable speed control suggested
6 - release pressure on DOWN button when unit stops	- unit stops automatically on reaching the bottom of the stairway - therefore no control action on part of operator needed	- feature satisfactory

(Continued)

TABLE 2
Task Analysis: Garaventa Lifts, Halifax; Kingston

(Continued)

Operations	Comments/Difficulties	Comments/Solutions
D - Unload w/c		
1 - remove control module jack	- no place to rest module while other operations performed - hence, load on memory, and risk of loss or vandalism - in Photographs 52, 53 and 58 note Kingston operator's tendency to keep module in one hand, thus making subsequent tasks awkward	- storage space for module needed at both ends of system, if module is to be retained as part of control system
2 - rotate anticlockwise and turn key	- another small task element placing load on memory - must remember also to put key in pocket	- as for A-3
3 - pull left hand lever on hanger to lower egress ramp	- as for A-6	- as for A-6
4 - release w/c brakes	- as for A-1 - must be done from front at Halifax because of railing	- as for A-1
5 - pull/push chair off ramp	- at Halifax, operator must pull - cannot get behind to push because of railing - therefore movement extremely awkward - risk of chair hitting tibia - even at Kingston, operation awkward as operator must start from higher than ground level (see Photograph 60)	
6 - brake w/c	- as for A-1	- as for A-1
7 - push left hand lever on hanger to raise egress ramp to vertical position		
8 - grab platform handle and raise into vertical position	- as for A-5	- as for A-5
9 - lock platform in place with padlock through handle	- as for A-4	- as for A-4
10 - insert key into latch	- turns power off and deactivates visual and audi-	tory warning stimuli - at Kingston, also raises
	on call station panel, and	striped gate at top and bottom of stairway
	turn anticlockwise	
11 - release w/c brakes, proceed	- as for A-1	- as for A-1

- Provide storage space for the control module (if it is to be used) and for other loose parts at both ends of the system.

- Modify system at Kingston to consist of one unit with movement continuous down one staircase, across the short level stretch between staircases, and up the other staircase.

As for the Cheney lift, operation of the Garaventa lift also entails frequent adoption of disadvantageous body positions and assymetrical distribution of physical load. Recommendations aimed at overcoming these undesirable task requirements are largely the same as those listed for the Cheney Stairway Lift. Of course those regarding the Cheney safety bar are irrelevant to the Garaventa. However, as some Halifax and Kingston volunteers indicated that a safety bar would be psychologically helpful in overcoming feelings of insecurity arising from the open nature of the lift, it may be that such a component will be added at these sites. If so, its designer is advised to consider seriously the nature of additional task stress which may be imposed on the operator.

(2) Passenger Evaluation

(a) Observations

The location of the Garaventa lift at Halifax is, like that of the Cheney lift at Ottawa, protected from observation by large numbers of passengers, the great majority of whom are routed in other directions. Therefore there is little opportunity for feelings of conspicuity to arise in the wheelchair passenger on this account. At Kingston, however, the lift is located in the main line of passenger traffic choosing to cross the tracks underground. Moreover, at this site, the yellow-black striped gates, flashing red lights, and high-pitched intermittent tone seem to announce either a frightful state of emergency or a daring circus act and encourage every passing head to turn in alarm or curiosity toward the system when in use. The attention drawn to the wheelchair passenger in this fashion can only tend to depersonalize her or him.

Apart from their attention-getting effects, these warning signals constitute strong sensory annoyance to the wheelchair occupant (to say nothing of the operator) and may alternatively create arousal effects which enhance anxiety. Although those at Halifax are not as intense or as attention-provoking as those at Kingston, they nevertheless elicited irritating sensory responses in the volunteer passengers. This is particularly true of the intermittent tone which shifts in localization so that it appears to be revolving about the head.

An intense depth perception effect was experienced by almost all volunteers at both sites where the staircases are much longer than that serviced by the Cheney lift in Ottawa. Photographs 30 and 31 will give the reader some idea of the situations at Halifax and Kingston respectively. However most of the volunteers were not unduly affected by this perception. In particular, those at Halifax, who constituted a young, problem-solving, and extremely active group, appeared ready and eager to add to their experiences in this world of complex gadgetry and high technology. Individuals such as these regard the lift as their way of overcoming a level change in order to attain some larger goal.

Still, experimentally induced depth perception commonly elicits avoidance responses in animals and very young infants, and it has been speculated that such responses have innate adaptive significance. Since learning does not always overcome these reactions, it is possible that they will surface strongly in some individuals confronted with the lift

situation at Halifax or Kingston. Agents in the former city indeed reported that some elderly passengers refuse to be taken to Customs via the lift. At Kingston, the anxiety experienced by one subject is clearly reflected in Photograph 61.

This subject, his perception of depth possibly intensified by heightened arousal due to sensory stimulation arising from the lights and tone, had fearful concerns about the reliability of the lift, particularly since it is obviously supported on only one side. As it happened, the weight of this passenger and his heavy electric wheelchair did indeed cause the platform to deflect sufficiently for the limit switch on the outside of the platform to be activated. However the switch permitting the ramp to be lowered was not; therefore it was necessary for the operator to lift the platform manually so that the ramp could be lowered. Such an event can only serve to increase the anxiety of an already tense passenger. The relief manifest in Photograph 62 in the face of the volunteer in question as he reached the bottom of the staircase, is notable!

Some concerns were expressed regarding the possibility of the cable breaking, or the power going off and being stuck mid way on the staircase. In addition, while one Halifax subject apparently preferred the open nature of the lift (as opposed to the claustrophobic conditions in an elevator), most - especially those at Kingston - indicated that this feature of the lift could induce a sense of insecurity which might be overcome, if only psychologically, by some of kind of safety bar. Jerk at startup, reported by most subjects at both sites, could add to anxiety feelings, as could lateral platform wiggle and sway of the chair on the platform (reported by Halifax volunteers) or sensation of forces during the 90° corner turning at Kingston (note the stress exhibited by the volunteer in Photograph 63 as this turn is executed).

Members of the Halifax sample were virtually unanimous in expressing a preference for operating the system themselves, this being more in keeping with their characteristic self-reliant approaches to life. Like the operators and some Kingston volunteers, they considered the movement of the lift to be exceedingly slow. Mention was made also that the cylindrical shape of the operating switch and its need for sustained pressure induced painful effects in the operating finger. Moreover movement of the switch did not appear to be perfectly correlated with movement of the lift; a consistent report was that the lift frequently stopped while the finger was still fully depressed against the switch.

Use of the optional seat, tested out at Kingston by one of the research team members (see Photograph 49), is likely to evoke in some frail or semi ambulatory passengers reactions which are similar to those described above for wheelchair passengers. A forward-facing position of the passenger would likely be preferred. Nevertheless, in the absence of other means of overcoming changes in level, including the optional seat in the system would appear to be worthwhile.

(b) Summary and Recommendations

The following recommendations are made regarding passenger reactions to the Garaventa lift:

- Assign responsibility of braking and unbraking, of wheeling on and off the platform and, where applicable, of controlling the movement of the lift to the passenger. It cannot be overemphasized that a co-operative approach to such a task is likely to reduce any sense of depersonalization or loss of independence which frequently arise in some individuals when their logistic problems are over-arranged for them.

- Modify the nature of the warning systems, especially at Kingston. The present system appears to be one of safety overkill, very much out of proportion to what is needed to warn pedestrian traffic. (The lift is slow moving, always operated in the presence of an attendant, and clearly visible from positions in the lift area.) However, some means should be found to keep passengers from rushing from the terminal through the door at the top of the stairs. It is suggested that a lighted sign on the terminal side of the door "Go Slowly - Wheelchair Lift in Use" would be more appropriate than the present sensorially jolting system which not only elicits undesirable attention to the wheelchair passenger, but also creates irritating visual and auditory sensations which, by increasing arousal, may tend to intensify fear reactions due to depth perception.

- Reduce intensity of warning tone at Halifax and eliminate its irritating localization-shift effect.

- Modify system, if possible, to overcome lateral movement and startup jerk. In particular the limit switches should be arranged so that a heavy load on the platform does not require manual relocation of the platform to a horizontal plane to enable the exit ramp to be lowered. Any features which are susceptible to malfunction or which result in uncontrolled movement will tend to undermine passenger confidence in the system and could produce pronounced fear reactions in some, particularly those already suffering from avoidance reactions due to depth perception.

- Develop mechanism to prevent instability of the wheelchair on the platform. The braking systems on wheelchairs are frequently inoperative, especially those of individuals who travel a good deal, as the chair may be subjected to undue pressure when stowed in the luggage compartment of vehicles.

- Install safety bar to overcome passengers' feelings of insecurity due to the open unprotected nature of the lift. At Kingston, it may be possible to develop a safety bar by redesigning the arm-rests of the fold-up seat (see Photograph 63).

- Redesign toggle control switch. It is suggested that a broader lever capable of accepting thrust from the entire hand would be preferable to the existing switch. However any redesign of the control system should, as suggested earlier, include significant input from a qualified ergonomist.

3.4 Economic Evaluation

The price to the dealer for the five Garaventa lifts in Canada that are located in transportation terminals has ranged between $11,000 and $15,500 per unit. In order to cover customized installation, other costs and profit it is estimated that these prices would be increased by 60-90% or even 100%. The consequent price for a single installation would thus be from a low of about $18,000 in a simple location with minimum mark-up, to in excess of $30,000. The cost of a double system, such as at Kingston, would obviously be approximately twice that of a single system, depending on the similarity of the two installations. This price could be reduced in some locations with the use of two sets of rails connected at the lower platform and the use of a single carriage assembly. Maintenance costs of this lift are minimal.

The Garaventa stairway lift is a sophisticated device and the price reflects this level of sophistication.

IV. SUMMARY OF COMPARISON AND RECOMMENDATIONS

1. Engineering Evaluation

Two different makes of inclined stairway lift have been evaluated. In general, both the Cheney and the Garaventa lifts are safe, functional and reliable devices. Due to its versatility, the Garaventa may initially appear to be a superior lift. The Garaventa lift is certainly an elegant design, however, it should be remembered that the Cheney lift at Ottawa is an old design and Cheney has a newer line of lifts available.

Some provincial elevator inspectors have reservations concerning the use of Type D stairway lifts in public buildings and favour the use of Type C lifts. In Quebec, only Type C lifts are permitted. In Ontario, the type of lift depends on the nature of the individual installation. However, fully enclosed runways (Type C) do make stairway lifts much less attractive and functional.

For retrofit applications, stairway lifts are a technically viable solution to the problem of facilitating level changes for the mobility handicapped at transportation terminals in Canada. At the Ottawa International Airport and the Kingston Railway Station, the nature of the stairwells required the use of an inclined stairway lift. However, at the Halifax International Airport, the layout of the stairwell area permitted other solutions. The stairwell area is shown in Photograph 64 with the Garaventa stairway lift installed. (See also Photograph 30.) The area to the right of the stairs (looking upward) is unused and would appear to be ideal for the installation of a vertical platform lift such as the Cheney Vertical Wheelchair Lift which is shown in Photographs 65 and 66. The use of a vertical platform lift having a fully enclosed runway (such as the Cheney Vertical Wheelchair Lift) is permitted in Standard B355 for vertical travel not exceeding 7000 mm. The Cheney lift is thus suited for this location.

The use of an enclosed vertical platform lift, such as the Cheney lift, has several advantages. The stairway is left totally unobstructed, the vertical lift can be used for other transportation purposes and attention is not focused on the user (as is the case with stairway lifts, especially when accompanied by barriers, lights and audio warnings). For the same reasons, vertical platform lifts (or elevators) would be preferable in new buildings where such devices could be incorporated into the structure during initial design.

From a purely engineering viewpoint both the Cheney and Garaventa lifts are sound devices. The Cheney lift is seen as a more functional workhorse while the Garaventa, due to its increased sophistication, is seen as somewhat less suited to the rigorous use of a transportation terminal.

2. Ergonomic Evaluation

2.1 Task Analysis

The most serious ergonomic considerations with respect to the Cheney and Garaventa lifts identified in this study relate to the operator's task rather than to passenger use. First, it was observed for both lifts that the operator must assume disadvantageous postures - sometimes under heavy physical load, especially in the case of the Cheney - the effects of which can accumulate over time to bring about permanent damage to muscles, tendons, ligaments, and joints in the shoulders, spine, and lower limbs. Remedial measures, outlined in previous sections, involve both design and procedural considerations. More immediate effects can also be expected in the form of bodily

distress which, most unfortunately, is apt to induce development of a negative attitude toward the disabled passenger.

Secondly, in the case of the Garaventa, efforts to make the lift failsafe have rendered the operator's task one which, by reason of its plethora of non-integrated routinized elements, places undue load on memory and other components of information-processing. Tasks of this nature not only represent an inefficient use of the operator's time and resources, but also tend to create a sense of tedium which could eventually form a fertile ground for negative feelings regarding the task and all associated with it, including the disabled passenger. Extensive design modification to the operational characteristics of the Garaventa lift are therefore necessary before it can be considered ergonomically suitable.

In sum, considering only the operator's task, the ergonomic view would be that neither the Cheney nor the Garaventa lift can be recommended without considerable qualifications for use in Canada's transportation terminals. A grave danger is that, in efforts to respond to pressure to accommodate the disabled, the ergonomics associated with the operational tasks are overlooked or ignored. Because complaining is socially undesirable, especially when it concerns the disabled, operators may attempt to cope with the additional physical and mental loads silently: the result can be damaging to the operator, as well as to the disabled passenger who may be seen as the cause of the operator's distress.

2.2. Passenger Evaluations

From the passenger viewpoint, some major ergonomic differences in the two lift systems relate to their sites rather than to the lifts themselves. To illustrate, as the staircases are much longer at Halifax and Kingston where the Garaventa lifts are installed, depth perception is much greater than it is at Ottawa where the Cheney lift is installed; therefore anxiety is apt to be greater in the former cases. Moreover this effect may be compounded by effects of the intense warning signals associated with the two Garaventa sites, particularly those at Kingston. Although nothing can be done about the configuration of the very structure the lift is meant to overcome, mild anxiety can likely be reduced with quiet reassurance by the operator regarding the safety of the device. However, such efforts are unlikely to be very effective in an environment like that at Kingston where visual and auditory warning stimuli are excessively intense. It is to be hoped that some compromise can be reached with respect to these signals.

The lifts themselves are associated with very similar ergonomic effects. Both have startup jerk, the disquieting effects of which are somewhat compounded by experience of movement of chairs with poor or no brakes and, in the case of the Garaventa, of lateral movement of the platform. Neither lift includes a safety bar in the design which, although not apt to provide any real support, may nevertheless have positive psychological effects. Both lifts have a control module with a cord which may sometimes constitute a minor annoyance to the passenger. Finally, as is necessarily true of any device for the disabled not operated by themselves, both are likely to induce a sense of loss of control on the part of the passenger. A mitigating influence with respect to this kind of feeling can likely be brought about by allowing the passenger to participate in the operating task as much as possible (e.g. by securing and releasing the brakes, wheeling on and off the platform, and operating the ascent/descent control switch as subjects did in Halifax), and/or by other ways reflecting an accepting and non-condescending attitude toward the passenger.

Briefly, there is little difference between the two types of lifts in terms of passenger reactions. Some modifications are advised, but these are relevant mainly to the particular sites investigated and to the procedures for handling passengers. Apropos of the latter, it is suggested that a sensitive attitude on the part of the operator will go a long way toward alleviating passenger anxiety, while this and a sharing of the operational task with the passenger will tend to reduce a feeling of paternalization. Despite these considerations, results of this study suggest that, although preference is for the elevator mode used by physically normal passengers, most of the disabled would view a stairway lift as their way of overcoming a level change which otherwise constitutes an obstacle to the larger sense of independence afforded by travel.

3. Economic Evaluation

The Cheney Stairway Lift III would appear to be considerably less expensive than the Garaventa Stairway Lift in terms of purchase and installation. The operating and maintenance costs of the two devices are not very different. It would appear that in most cases there is no economic justification to go to the more expensive device. The Garaventa lift does have the flexibility of being able to negotiate corners in the stairway and thus is required in some locations, such as the Kingston VIA station.

V. CONCLUSION

The automated stairway-mounted wheelchair elevating devices evaluated in this study undoubtedly increase accessibility for disabled persons in transportation terminals, but they are not faultless. The devices are mechanically sound and generally perform the required service but they are not universally well accepted by both operators and passengers. Where there are alternatives these are often preferred and where no alternative exists some operators use the devices grudgingly.

There are ergonomic problems with the lift, principally related to operator tasks, especially the bending actions required in lowering and raising the platform. Although the stresses associated with disadvantageous postures are difficult to totally eliminate, any reduction in platform weight would be advantageous.

The complexity of the numerous small tasks required for operation of the lift undoubtedly contributes to the reluctance of many operators to use the lifts. Due to the large number of personnel who may be required to operate the lift, and its relative infrequency of use in some locations, many operators may not be fully familiar with operating procedures. This leads to reluctance on their part to use it, especially if an alternative exists, and increased tension by the passenger who may perceive the operator's lack of confidence.

The stairway lifts are by no means inexpensive, especially the Garaventa lift. It is likely that in many installations the use of a stairway lift is the most cost effective alternative despite the inherent problems, however careful consideration should be given to all other access means. The use of an enclosed elevating device (such as the Cheney Vertical Wheelchair Lift) is likely appropriate in many instances and avoids a number of the problems associated with the stairway lifts.

In conclusion it is strongly suggested that inclined stairway lifts are not appropriate for installation as original equipment in the design and construction of transportation terminals, but may have a valid application as retrofit devices. Each potential site must be carefully reviewed and where possible it is suggested that vertical elevators or wheelchair lifts are used. Where inclined stairway lifts are installed every effort should be made to minimize the complexity of operation, within the limits imposed by Provincial codes and other applicable guidelines and standards. The devices, to be efficient, must be safe, perceived to be safe, convenient to operate, unobtrusive and capable of an appropriate speed. Due to the rough duty cycle and the many different operators that will be required to utilize the device, the utmost attention should be paid to reliability.

Stairway lifts can only be installed, however, where the stairway is of sufficient width. Unfortunately the lift is generally required at the same time as the stairway is being used by ambulatory persons and significantly reduces the stairway capacity by blocking one section of the stairway. Before a decision is made to install a stairway lift, sufficient observations of peak traffic movements must be made and the effect of the lift on these volumes should be determined.

Both of the devices evaluated are considered to be appropriate for short flights of stairs where no alternative exists, but are much less desirable for longer flights due to their speed and the depth perception of passengers. Where vertical lifts can be utilized they are preferable to the stairway lifts.

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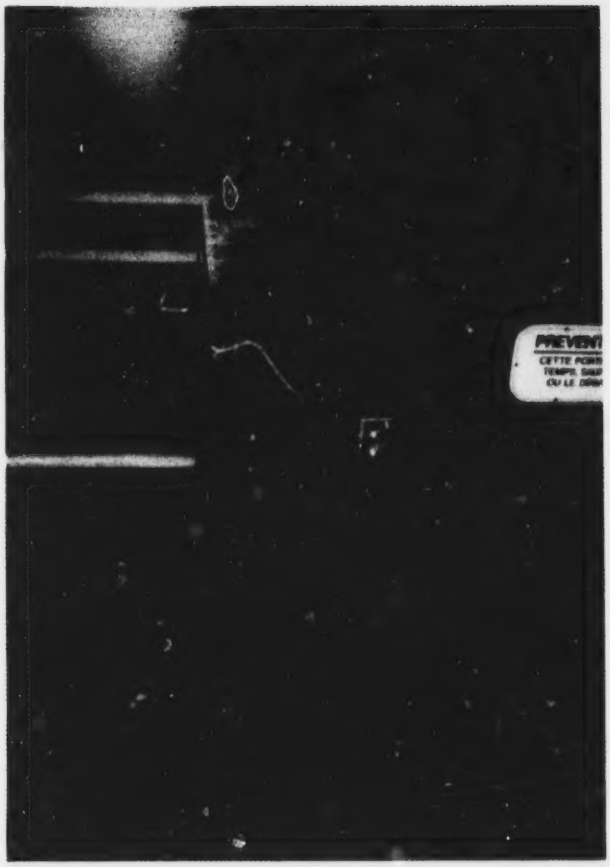
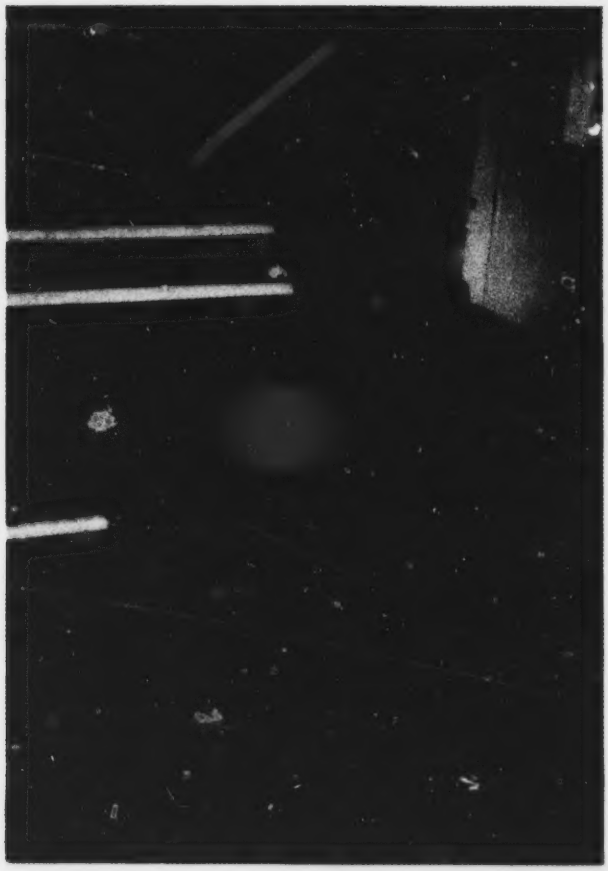


PHOTOGRAPH 1
Cheney Stairway Lift III (Folded)



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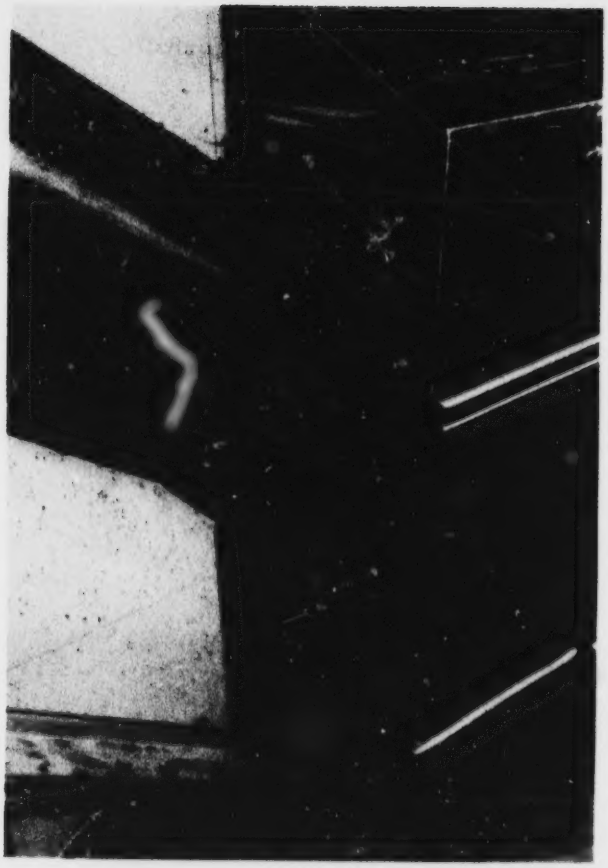
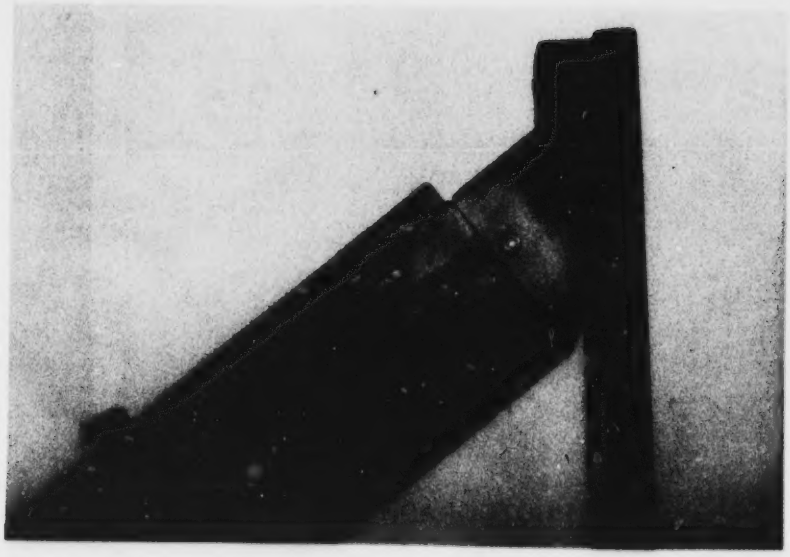
Cheney Stairway Lift III (Unfolded)



PHOTOGRAPH 3
Cheney Stairway Lift III
Latch Mechanism/Support Rails



PHOTOGRAPH 4
Cheney Stairway Lift III
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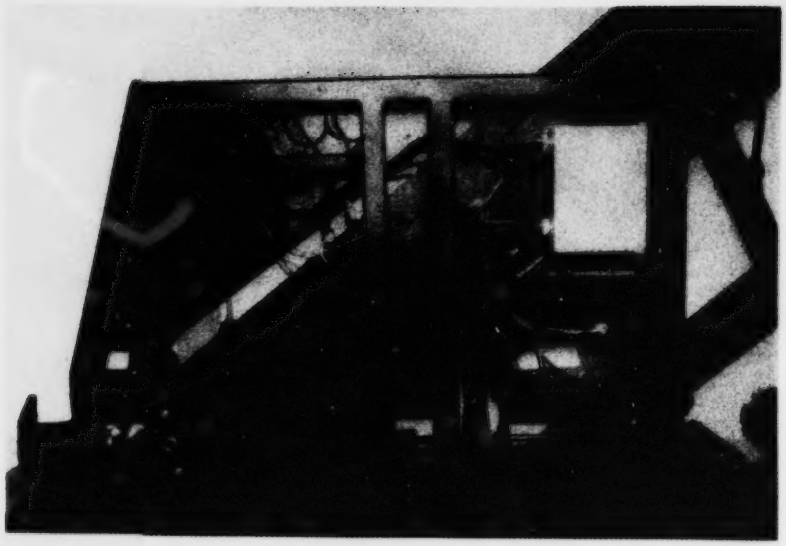

PHOTOGRAPH 5
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PHOTOGRAPH 6
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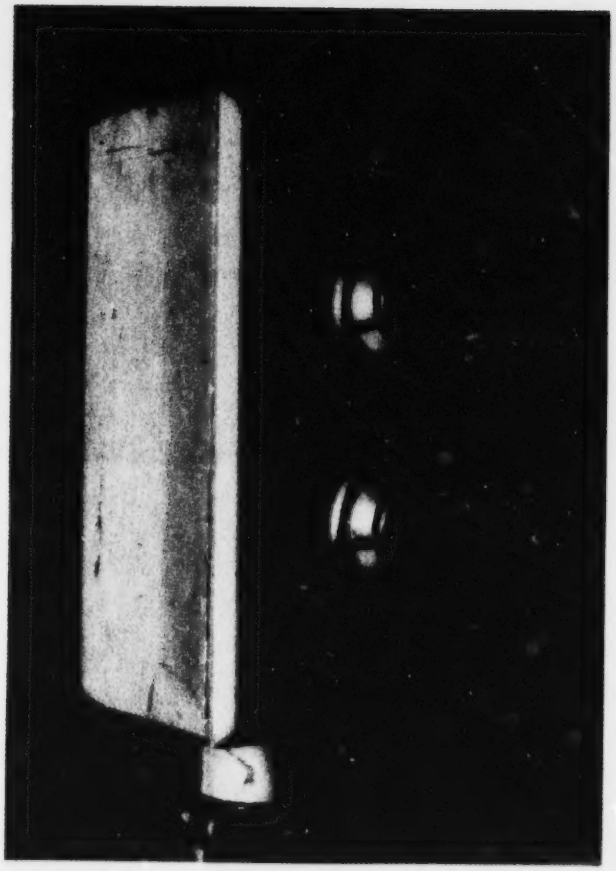

PHOTOGRAPH 7
Cheney Stairway Lift III
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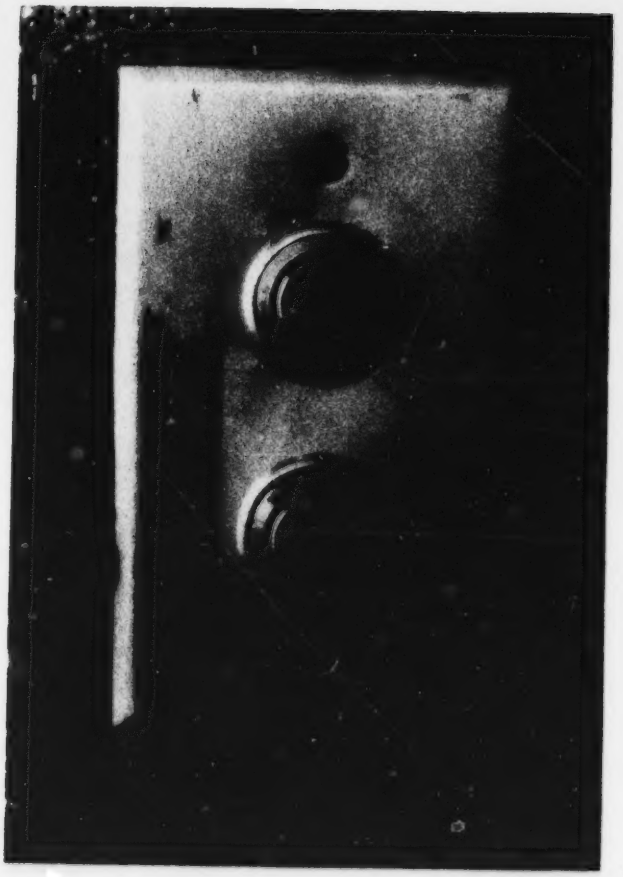

PHOTOGRAPH 8
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Cheney Stairway Lift III
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PHOTOGRAPH 10
Cheney Stairway Lift III
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PHOTOGRAPH 11
Cheney Stairway Lift III
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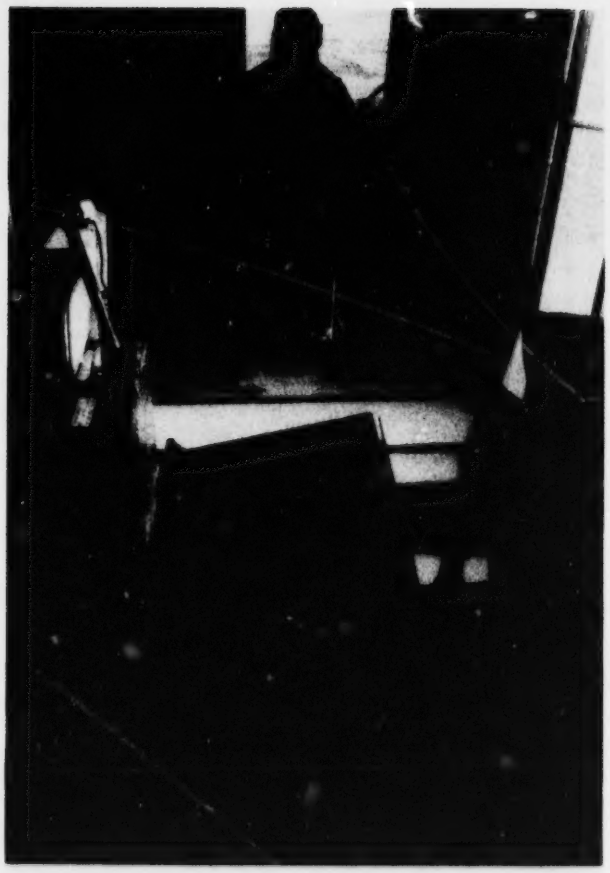

PHOTOGRAPH 12
Cheney Stairway Lift III
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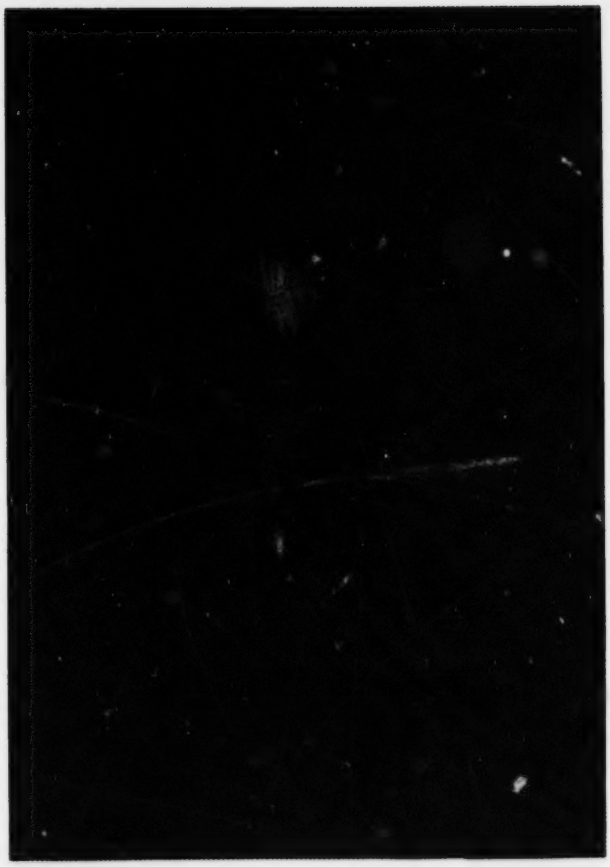
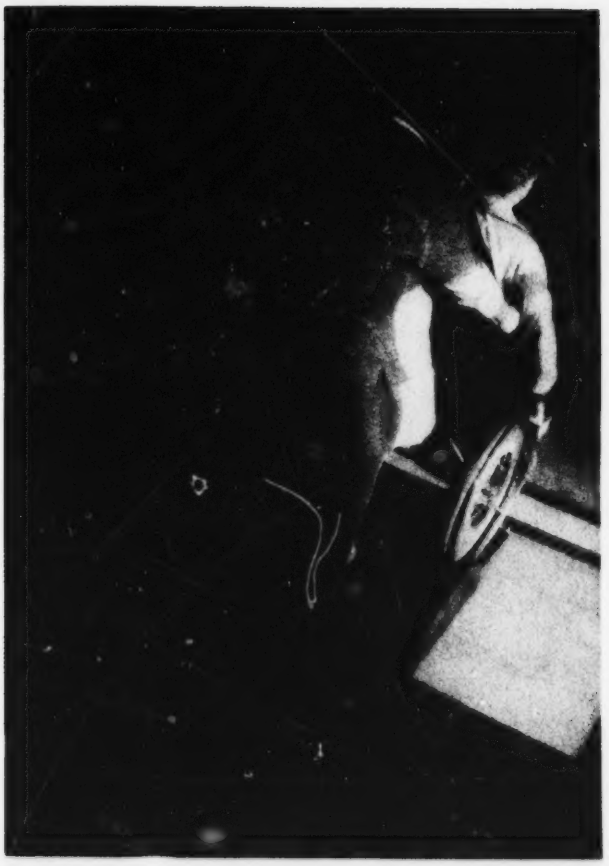


PHOTOGRAPH 13
Cheney Stairway Lift III
Operator Lowering Platform



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Cheney Stairway Lift III
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PHOTOGRAPH 17
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PHOTOGRAPH 18
Cheney Stairway Lift III
Safety Bar Resting
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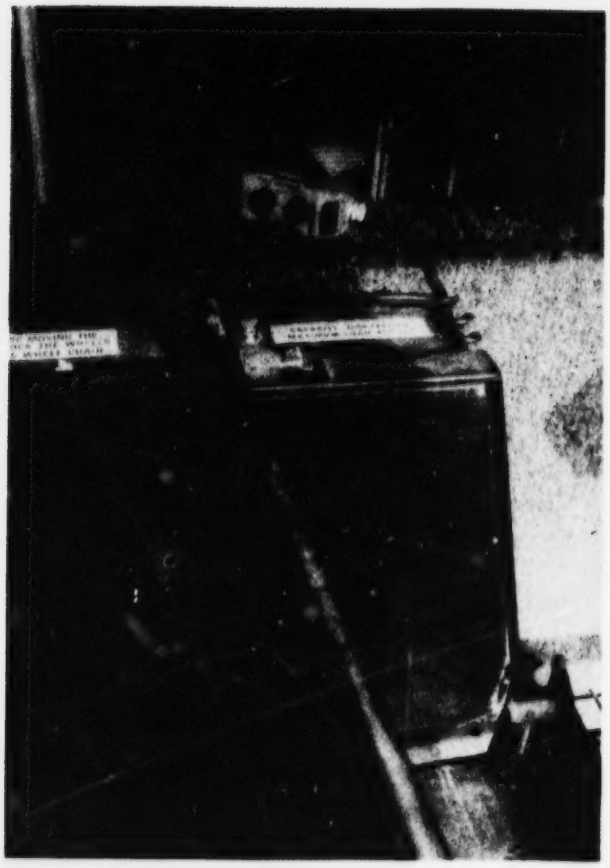

PHOTOGRAPH 19
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Cheney Stairway Lift III
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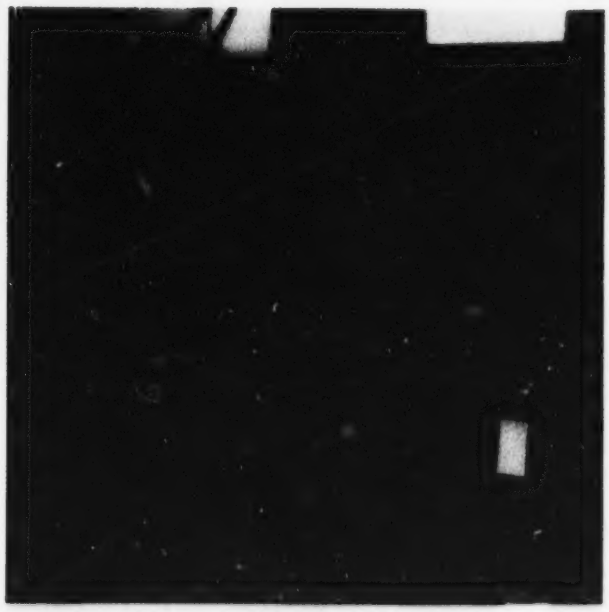
On Module



PHOTOGRAPH 22
Cheney Stairway Lift III
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Alongside Platform

PHOTOGRAPH 23
Cheney Stairway Lift III
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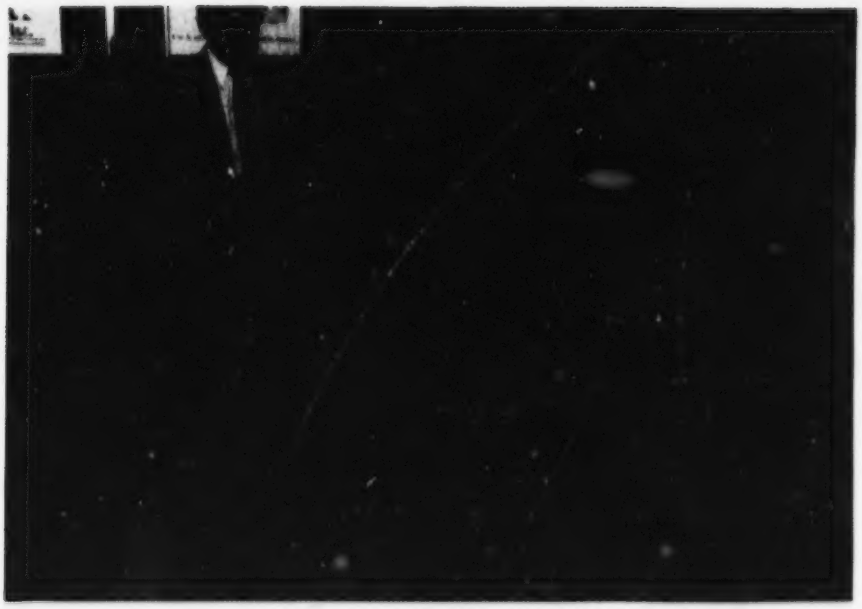
Off Platform



PHOTOGRAPH 24
Cheney Stairway Lift III
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PHOTOGRAPH 26
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Cheney Stairway Lift III
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Garaventa Stairway Lift (Folded)
(Kingston)

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Garaventa Stairway Lift (Unfolded)
(Kingston)

PHOTOGRAPH 30
Garaventa Stairway Lift
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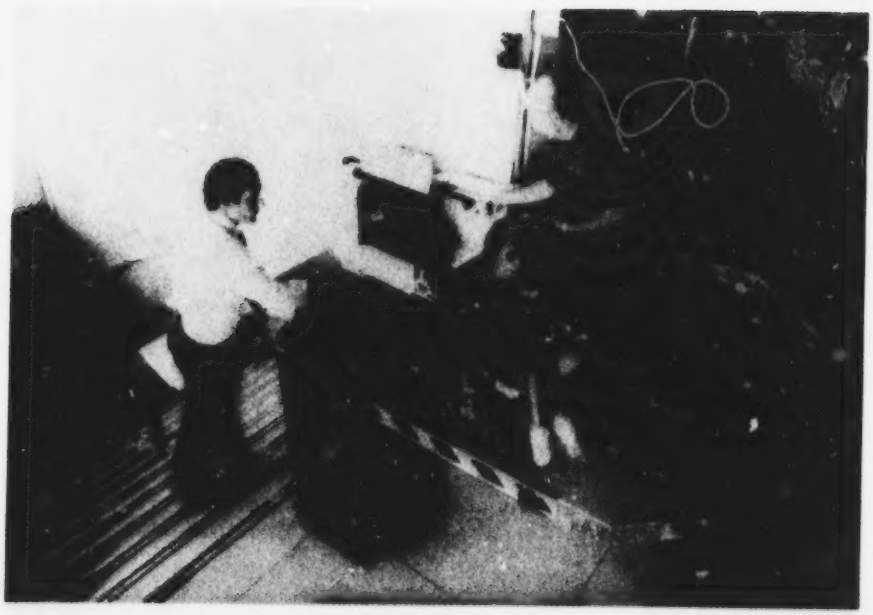
(Halifax)

PHOTOGRAPH 31
Garaventa Stairway Lift
Support Rails and Securement
(Kingston)



PHOTOGRAPH 32
Garaventa Stairway Lift
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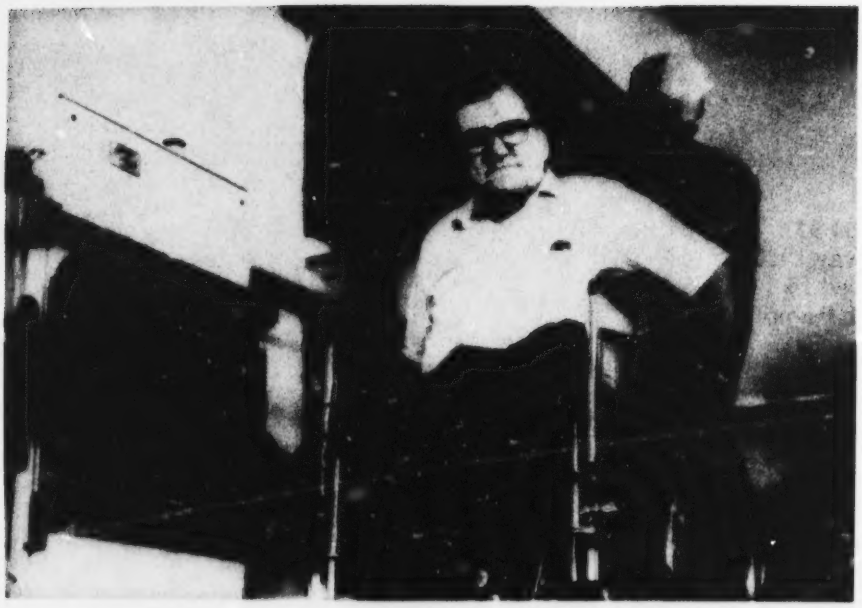
Egress and Showing
Upper Barrier (Kingston)



PHOTOGRAPH 33
Garaventa Stairway Lift
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PHOTOGRAPH 34
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(Halifax)

PHOTOGRAPH 35
Garaventa Stairway Lift
Lever Positioned to
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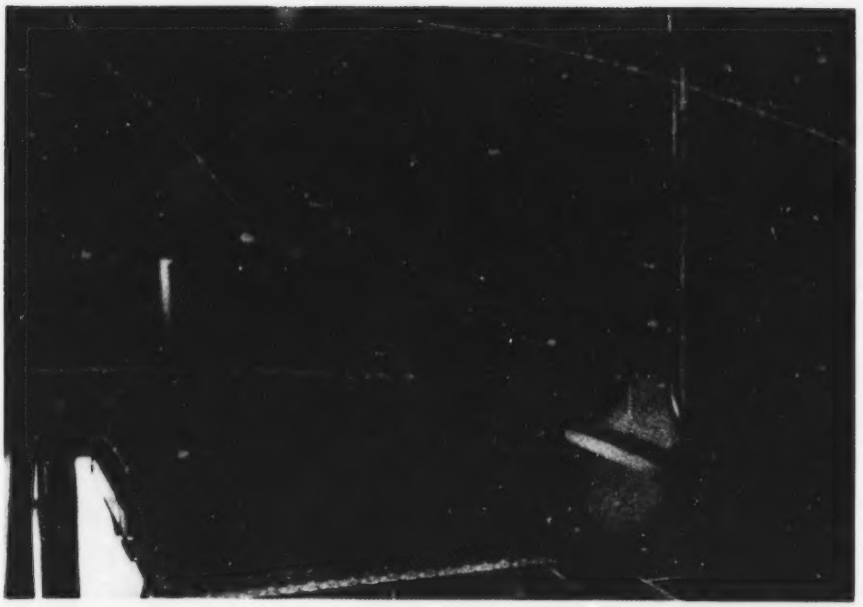
(Halifax)



PHOTOGRAPH 36
Garaventa Stairway Lift
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PHOTOGRAPH 37
Garaventa Stairway Lift
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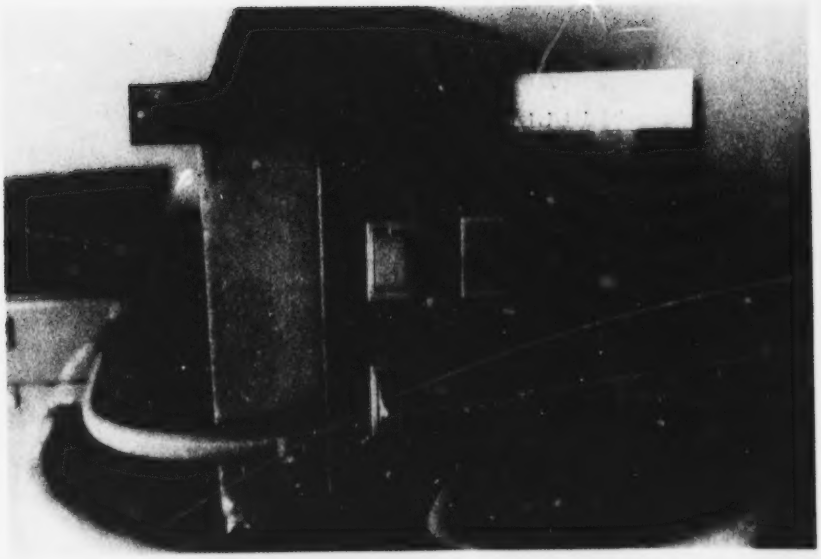
(Kingston)



PHOTOGRAPH 38
Garaventa Stairway Lift
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PHOTOGRAPH 39
Garaventa Stairway Lift
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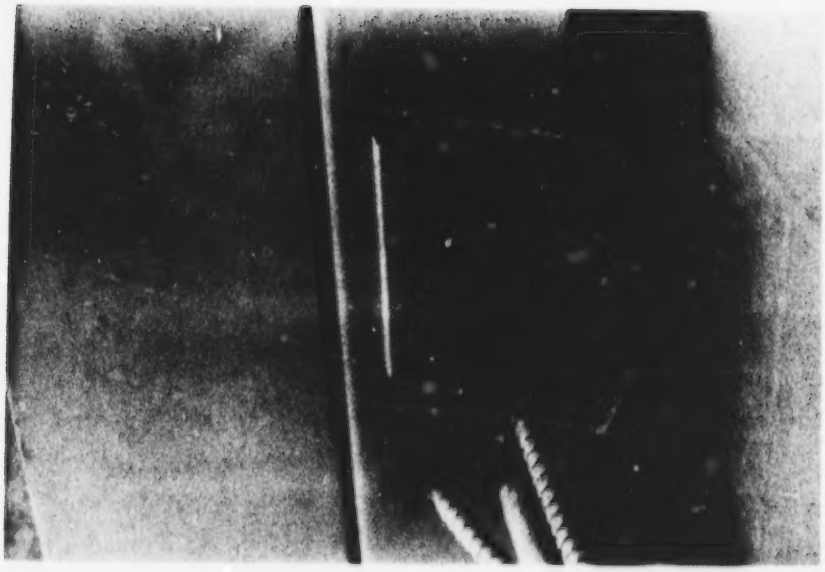

PHOTOGRAPH 40
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PHOTOGRAPH 41
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PHOTOGRAPH 42
Garaventa Stairway Lift
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(Halifax)

PHOTOGRAPH 43
Garaventa Stairway Lift
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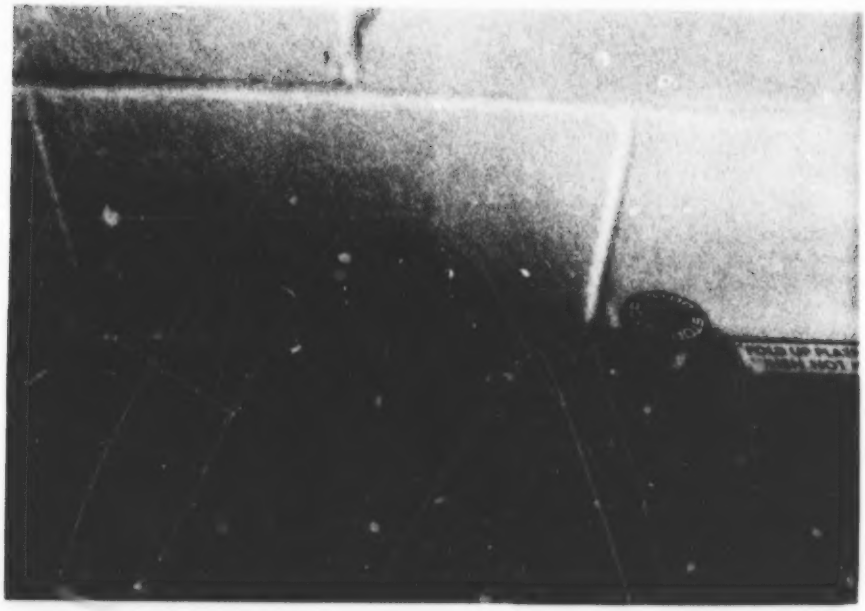
(Halifax)



PHOTOGRAPH 44
Garaventa Stairway Lift
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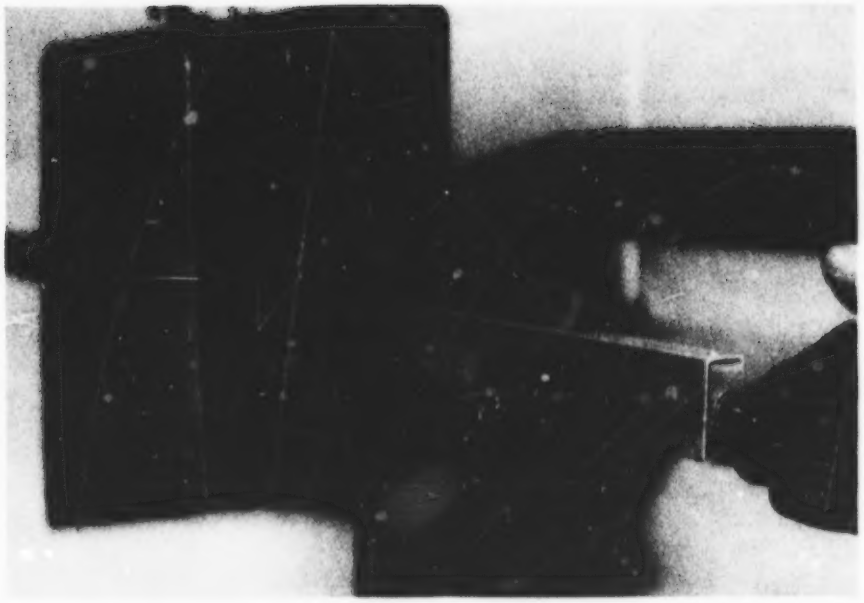

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Garaventa Stairway Lift
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Garaventa Stairway Lift
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Folding Seat, Arm Rests
and Lap Belt
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PHOTOGRAPH 50
Garaventa Stairway Lift
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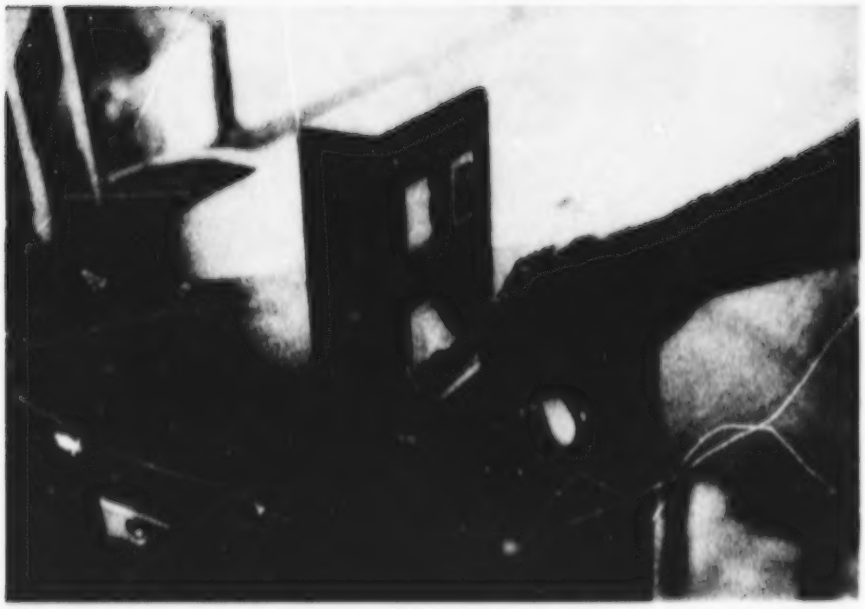

PHOTOGRAPH 51
Garaventa Stairway Lift
Turning On Key
(Kingston)

PHOTOGRAPH 52
Garaventa Stairway Lift
Operator Unlocking Padlock
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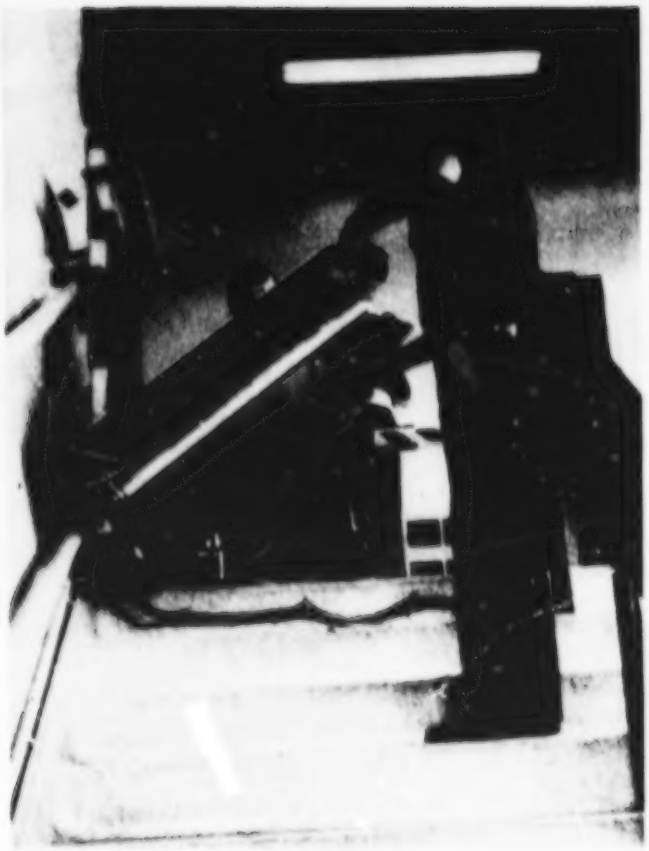
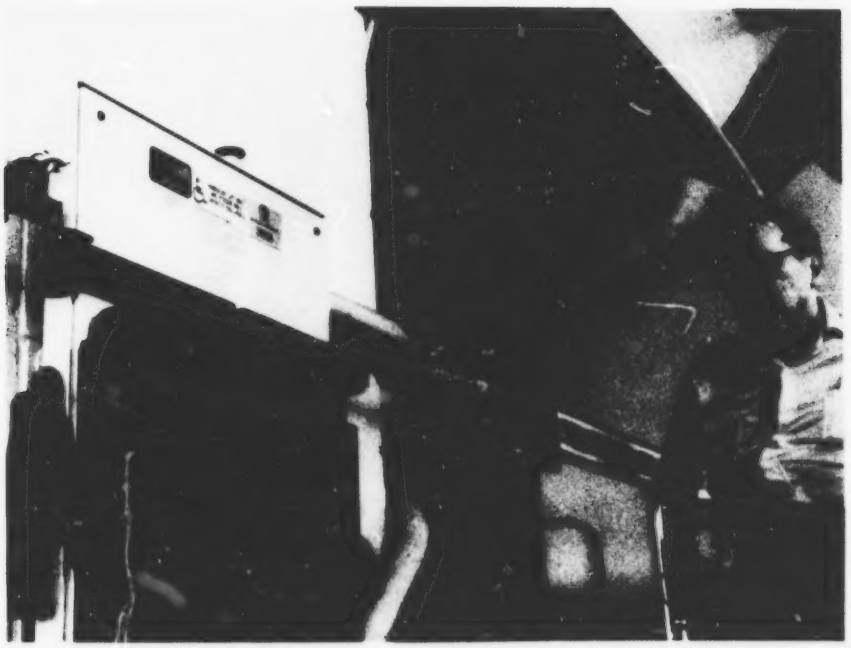
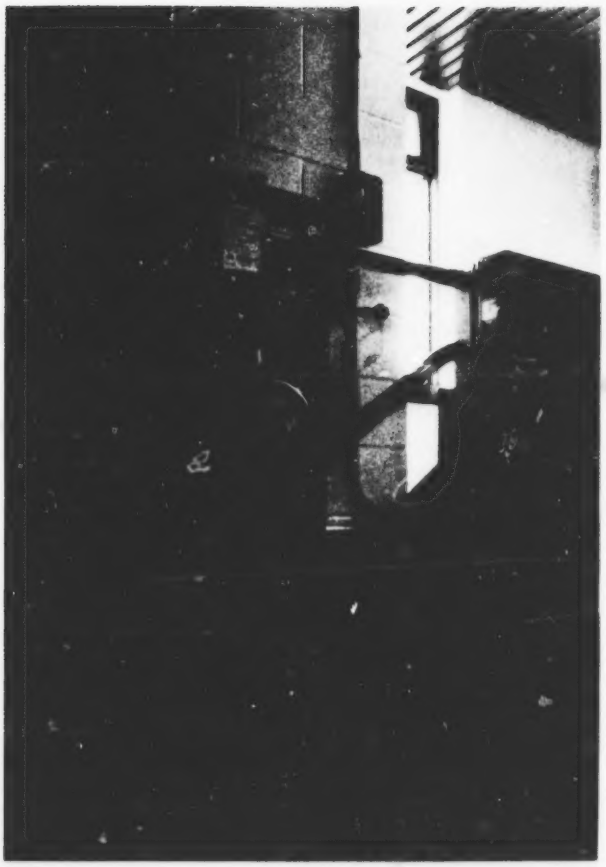


PHOTOGRAPH 53
Garaventa Stairway Lift
Operator Lowering Platform
(Kingston)

PHOTOGRAPH 54
Garaventa Stairway Lift
Operator Lowering Platform
(Kingston)



PHOTOGRAPH 55
Garaventa Stairway Lift
Operator Lowering Ramp
By Pulling Out Handle
(Kingston)



PHOTOGRAPH 56
Garaventa Stairway Lift
Ramp Control Levers
(Halifax)

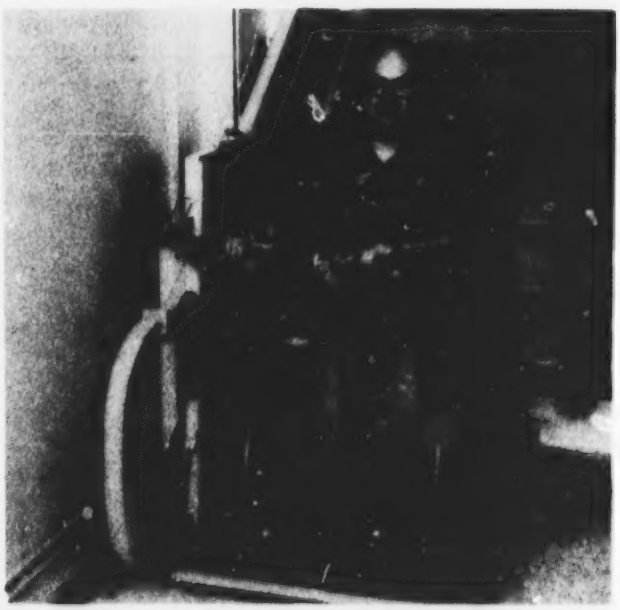
PHOTOGRAPH 57
Garaventa Stairway Lift
Operator Pushing Wheelchair Onto Platform
(Kingston)

PHOTOGRAPH 58
Garaventa Stairway Lift
Operator Applying Wheelchair Brakes
(Kingston)

PHOTOGRAPH 59
Garaventa Stairway Lift
Operator Inserting Key
in Hanger Control
(Kingston)

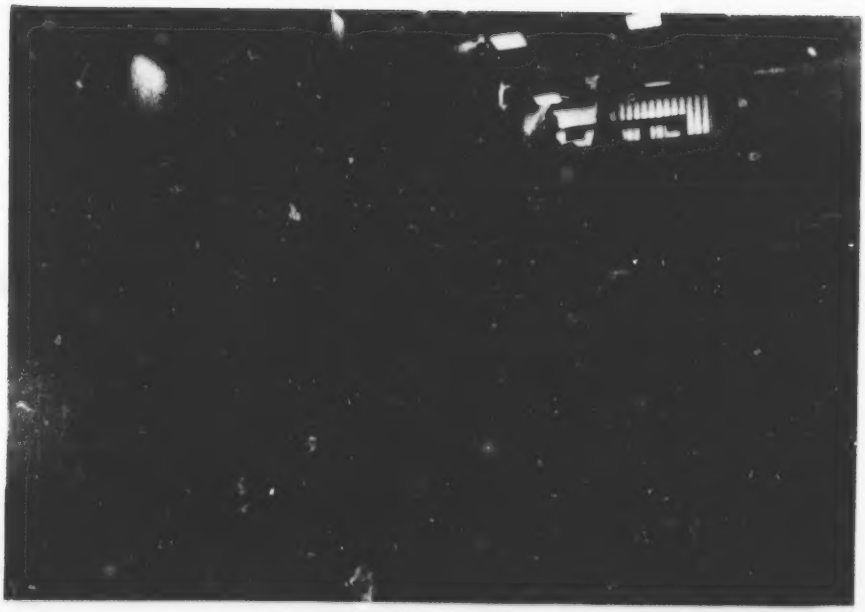
PHOTOGRAPH 60
Garaventa Stairway Lift
Operator Pushing Wheelchair
Off Platform
At Lower Landing
(Kingston)

PHOTOGRAPH 61
Garaventa Stairway Lift
Subject Exhibiting
Tension On Descent
(Kingston)



PHOTOGRAPH 62
Garaventa Stairway Lift
Subject Portraying Reduced Tension
on Reaching Lower Landing
(Kingston)

PHOTOGRAPH 63
Garaventa Stairway Lift
Subject Indicating Anxiety
On Descent
(Kingston)



PHOTOGRAPH 64
Stairwell Area
at Halifax Airport

PHOTOGRAPH 65
Cheney Vertical Wheelchair Lift
Open Position

PHOTOGRAPH 66
Cheney Vertical Wheelchair Lift
Open Position